Exploring Foundation Life Science student performance: Potential for remediation?

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DECLARATION

I, Nicola Frances Kirby, hereby declare that this dissertation is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

This research was conducted on the Pietermaritzburg campus of the University of KwaZulu-Natal in fulfillment of the requirement for the degree Doctor of Philosophy of Education under the supervision of Doctor Edith Dempster.

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ABSTRACT

This study is postpositivist. Adopting an ontological framework of critical realism requires the researcher to take the position of “modified” objectivist, and explore opportunities for the qualitative interpretation of quantitative data. Grounded theory is explored as the primary methodological approach, and as such the study takes on an inductive, theory-generating form in an attempt to describe and explain student performance within the context of alternative access to tertiary science studies.

True to grounded theory, the researcher begins the study without a theoretical framework, this being built as the study progresses. The researcher’s experience of teaching educationally disadvantaged students Foundation Biology in the Centre for Science Access on the Pietermaritzburg campus of KwaZulu-Natal is used as a starting point, from which the initial research question emerges, namely the performance of the Access students in a first-year Life and Environmental Science stream module relative to direct entry students.

Results from quantitative data analysis on students’ final marks in the first-year module pose a second research question: what factors contribute to the differing success of the student groups in the first-year module? Drawing on extant international and South African literature on factors affecting university student performance in conjunction with Regression Tree Analysis on the first-year module final mark, a theoretical framework begins to emerge. The concept of the “advantaged disadvantaged” calls for the notion of Access to be reconsidered, and curriculum responsiveness is examined in some detail.

Grounded theory method of constant comparison, seeking core categories, together with efforts of triangulation prompt the third line of enquiry, specifically to establish what factors are influencing the performance of the Foundation students in their Access year. Using students’ final Foundation marks as the outcome variable, further Classification and Regression Tree analysis is conducted, including biographical, socioeconomic, school history, and academic factors as well as a measure of student motivation. In addition, literature around Access contributes to theory building. This systematic abstraction and the conceptualization of empirical data result in a substantive theory: that it is English language proficiency, above all other possible variables that can best explain Life Science (Biology) student performance.

Selection into the Foundation Biology module is found to be at odds with selection into the Programme as a whole, necessitating curriculum responsiveness at the modular level. The emergent grounded theory, and the notion of "fuzzy generalization", seen to be appropriate to critical realist research, allows opportunities to explore remediation in the curriculum on the basis of these research findings. Attention is paid specifically to scaffolding literacy in biology through a "learning to read", "reading to learn" approach. These measures are dicussed within the context of assisting students to achieve epistemic access that will enable them to successfully participate in the academic practice of Science.

> *...He said that compared to individual witness and individual feelings, the compiling of statistics might seem dry. But those stirred not only the imagination but the reason, and the will to act. Statistics was a human science. It had begun, he rather thought, with Durkheim, noticing that the number of suicides in Paris did not vary from year to year. All of them different human creatures, all of them grim decisions taken that life was no longer bearable. The causes might be poverty, lost love, failure at business, humiliation or sickness. But the figure was the same.*
>
> *In the case of poverty the compilation of figures touched the imagination in a way individual cases could not. The hero of this study was Charles Booth who had interviewed everybody — registrars, school attendance officers, School Board visitors, census-takers, and had produced, beginning in 1892, seventeen volumes of report on the nature and extent of poverty in London. He had mapped it street by street, colouring the streets according to the data, and had come to the conclusion that a million people, over 30 per cent of the population of London, had not the wherewithal to subsist or continue living. This figure revealed an unjust society as individual descriptions alone could not.*
>
> *It was a prerequisite for putting forward constitutional and legal changes — the introduction of a pension for the aged in place of the foul and degrading Workhouse, the suggestion of minimum legal wages, and maximum hours of work, of help for the unemployed that was ration ally administered and not a function of charitable impulses amongst the better-off.*
>
> Byatt, A. S. (2009). *The Children's Book*. London: Random House

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ACRONYMS

AARP	Alternative Admissions Research Project
ANA	Annual National Assessment
ANOVA	Analysis of Variance
AP	Augmented Programme
APS	Admission Points Score
ASSAf	Academy of Sciences of Southern Africa
BICS	Basic Interpersonal Communication Skills
BIOL 099	Foundation Biology module (Science Foundation Programme stream)
BIOL 101	The Smaller Side of Life module
BIOL 195	The Smaller Side of Life module, BSc4 (Augmented) stream
BIOL 199	Foundation Biology module, BSc4 (Foundation) stream
BSc	Bachelor of Science
BSc4 (Augmented)	Augmented stream of the Extended Curriculum Programme
BSc4 (Foundation)	Foundation stream of the Extended Curriculum Programme
CALP	Cognitive Academic Language Proficiency
CAM	Continuous assessment mark
CAPS	Curriculum and Assessment Policy Statement
CART	Classification and Regression Tree
CRT	Classification and Regression Tree
CSA	Centre for Science Access
CHE	(The South African) Council of Higher Education
CHET	Centre for Higher Education Transformation
DP	Duly Performed (certificate)
DA-EFL	direct access English First Language
DA-ESL	direct access English Second Language
DBE	Department of Basic Education
DET	Department of Education and Training
DMI	Division of Management Information
DOE	Department of Education
ECD	Early Childhood Development
EFL	English First Language
ERS	Examinations of Results Schedule

ESL	English Second Language
ESP	English for Specific Purposes movement
EST	English for Science and Technology movement
FET	Further Education and Training phase
FETC	Further Education and Training Certificate
FP	Foundation Programme (ex-FP: ex-Foundation Programme)
GEPS	General Entry Programme for Science
GET	General Education and Training
GT	Grounded Theory
HDI	Human Development Index
HESA	Higher Education South Africa
HEQC	Higher Education Quality Committee
HG	Higher Grade
HSRC	Human Sciences Research Council
ISM	Inventory of School Motivation
ITS	Integrated Tertiary Software
KMO	Kaiser-Meyer-Olkin
L1	First/home language
LES	Life and Earth Sciences
LoLT	Language of Learning and Teaching
LSD	Least-Squared Deviation
"M score"	Score defined by matric maths and science admission point scores only.
MANOVA	Multivariate Analysis of Variance
NATED	National Assembly Training & Education Department
NBT	National Benchmark Test
NBTP	National Benchmark Tests Project
NCHE	National Commission on Higher Education
NCS	National Curriculum Statement
NMMU	Nelson Mandela Metropolitan University
NQ	National Quintile
NQF	National Qualifications Framework
NRF	National Research Foundation
NSC	National Senior Certificate
OBE	Outcomes-based Education

OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
PIRLS	Progress in the International Reading Literacy Study
PRAESA	Project for the Study of Alternative Education in South Africa
SAARMSTE	Southern African Association for Research in Mathematics, Science and Technology Education
SAQA	South African Qualifications Authority
SATAP	Standardised Assessment Test for Access and Placement
SAUVCA	South African Universities Vice-Chancellors Association
SC	Senior Certificate
SFP	Science Foundation Programme
SG	Standard Grade
SMS	Student Management System
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TAI	Technology Achievement Index
TELP	Tertiary Education Linkages Project
TIMSS	Trends in International Mathematics and Science Study
UCT	University of Cape Town
UDW	University of Durban Westville
UFP	(Nelson Mandela Metropolitan) University Foundation Programme
UKZN	University of KwaZulu-Natal
UMALUSI	General and Further Education and Training Quality Assurance Council
UN	University of Natal
UNP	University of Natal, Pietermaritzburg campus
UNDP	United Nations Development Programme
UNIFY	University of the North Access Programme
UTLO	University of KwaZulu-Natal Teaching and Learning Office
WITS	University of the Witwatersrand

FOREWORD

When I was first appointed to my teaching position in the Science Foundation Programme (SFP) at the University of Natal, Pietermaritzburg, I had absolutely no idea what a journey I was beginning. As a novice tutor, having no formal degree in Education, and determined to better equip myself for my position of employment, I registered for an introductory module offered by the Centre for Higher Education Studies (CHES). Completing this module in higher education practice set in motion an interest and investment in teaching, which has evolved in the context of educational disadvantage.

For a number of years, on an ad hoc basis, and as my teaching commitments and personal circumstances allowed, I continued with the modules offered by the Faculty of Education and CHES, and found them stimulating and of enormous benefit to my teaching philosophy and pedagogy. With increasing investment in the SFP, I also familiarized myself with the original literature written by those who were responsible for the inception the Programme at the University of Natal (Pietermaritzburg) (e.g. Grayson 1996; 1997). This required me to engage with Constructivism and Vygotskian views of social learning in particular, these being the theoretical underpinnings of the Programme in which I was teaching.

With my growing pedagodic awareness, and true to grounded theory methodology, questions about Foundation student performance in their mainstream studies began to emerge from my working environment. Working within a Science Faculty where quantitative methods are hegemonic, I needed to master inferential statistics; an area that was a huge personal stumbling-block in my tentative foray into research. Whilst learning about statistics and quantitative method, I, like the majority who make an automatic connection between quantitative research and Positivism, was drawn into the literature critiquing this philosophical and paradigmatic research position. I was surprised and excited by what I read, and drawn by the writings of D.C. Phillips in particular, into postpositivism. Similarly, as most research novices are sure to do, my starting point for exploring the ontic and epistemic frameworks of postpositivism was Guba and Lincoln (2005). And thus I was exposed to the ontology of critical realism (see Guba and Lincoln, 2005, p.193) which in turn led to my immersion in the literature with this focus.

With renewed interest, I found myself re-examining the philosophical basis of the Foundation Programme (Kirby & Dempster, 2012), and recording my own deliberations around positivism, postpositivism and critical realism (Kirby, in press).

By the time I had conducted my initial analysis on the performance of my Foundation students in mainstream, I was well immersed in the literature around research paradigmatic choices. I had also come across Yeung (1997), which resonated with my new understanding of postpositivism and critical realism, and introduced me to the idea that grounded theory has methodological potential in critical realist research.

So my attention turned to exploring the history of grounded theory and its proponents Anselm Strauss, and his less well-known counterpart Barney Glaser (Glaser & Strauss, 1967/1999). Grounded theory is widely recognized to be theory building rather than theory testing, and indeed, was developed as an alternative approach within the positivist tradition (Nieuwenhuis, 2007). So it was with particular interest that I read of the postpositivistic location of the initial conceptions of grounded theory (e.g. Annells, 1997; Henning, 2004; Kennedy & Lingard, 2006; Denzin & Lincoln, 2005). The bulk of contemporary grounded theory is however, the constructivist version of this methodology (e.g. Charmaz, 2005), research conducted in the tradition of Strauss. However, Glaser has continued to make his own case for quantitative grounded theory (e.g. 2008).

With my own new understanding of postpositivism, and my vastly improved comprehension, and command, of statistical analysis of quantitative data, I was able by the beginning of 2010 to interpret my data with a critical realists' perspective. For example, I was able to employ effect sizes of the differences between means over the significance of these differences.

But I was still in search of a quantitative method that could best explore, in the context of critical realist research, the relative influence of different factors on my students' academic success. I needed a non-parametric alternative to generalized linear modelling techniques conventionally used. Indeed, as Pascarella & Terenzini (1998, p. 155) warn, research approaches that try to isolate the influences of a few variables for all students will simply miss the point and probably provide little in the way of useful, practical or policy relevant evidence". Ma (2005) provided me the solution in the form of classification and regression tree analysis. Using this form of quantitative data analysis, I began to see iterations and elaborations of what I had initially found when using a different method to investigate

Foundation student success in mainstream. With each emergent picture revealing the interaction between the various influences affecting student performance, afforded me by the classification and regression trees, iterative abstraction was indeed possible. A concurrent engagement in international and South African literature on epistemological access and mainstream responsiveness to the challenges faced by tertiary institutions in this country added to my emergent grounded theory. Yeung (1997) makes it clear that two other methods for pursuing critical realist research are "iterative abstraction" (p. 58) and triangulation (p. 64). After years of exploration, it seemed I had found my way through to a philosophically and methodologically sound framework to explore my Foundation student performance and possible ways of enhancing their success at gaining epistemic access to tertiary study.

I did not originally intend that my research endeavour should culminate in a dissertation towards a doctoral degree in Education. I set out simply wanting get an idea of whether I was doing a sufficiently good job in preparing my Foundation students for first year. But, as you will read, it has been a long journey, and one I began to feel in 2011, that should be properly, and inclusively documented in the form of a dissertation. I believe I have grown much as a researcher along the way. From very naïve beginnings, like Morrow (2007e, p. 11), who "had the arrogant impression that he (I) was a trailblazer" in his reflections on teaching in higher education, I too have discovered that "out there in the big world there is a flourishing debate" (ibid) around issues of epistemic access. I hope that my work may add constructively to this debate.

CHAPTER 1

Research Context

The Centre for Science Access, University of KwaZulu-Natal, Pietermaritzburg, South Africa

Redress and Access Programmes in South Africa

The passing of the Black Education Act (Act 47 of 1953) (Buckland, 1982; Behr 1984) initiated a crisis in South African teaching programmes that has had severe consequences for generations of students. By the mid 1980s a relaxation of admission of black African students to traditionally white universities was applied (Rutherford & Watson, 1990) in an attempt to address the "gross inequalities between black and white systems" after decades of segregation, ideological neglect and rising pupil numbers in black schools (Hofmeyer & Spence, 1989). In spite of this, the number of black African students majoring in science subjects remained very low in the 1990s (Altink, 1987; Department of Education (DOE), 1997a; Grayson, 1996; Zaaiman, 1998), a consequence of this being a national shortage of these graduate scientists in industry, nature conservation and education. This under-representation of black African science graduates in South Africa continues to be a matter of concern (Downs, 2005; Downs, 2010; Mabila, Malatje, Addo-Bediako, Kazeni, & Mathabatha, 2006; National Research Foundation (NRF), 2009; Organisation for Economic Co-operation and Development (OECD), 2008; Scott, Yeld & Hendry, 2007; Simkins, Rule & Bernstein, 2007). Furthermore, at school exit level, there is still a large proportion of black African students who are underprepared for tertiary study. Problems concerning the legacy of apartheid education, and the shortcomings of the post-apartheid schooling system, have been highlighted by many authors (e.g. Kloot, Case & Marshall, 2008; Jansen, 2011; Sanders, 2006; Simkins et al., 2007; Soudien, 2007), with obvious implications for the quality and capability of students attempting to gain access to tertiary institutions.

Indeed, the "new" outcomes-based curriculum known as the National Curriculum Statement (NCS)[1] has encouraged a move away from passive, rote learning and teacher-centred, content transmission approaches, these being the traditional modes of learning and teaching in pre-democracy classrooms in South Africa (Crewe, 2010; Umalusi, 2010a;

Venter, 2001). However, it is generally agreed that implementing such a "learner-centred and activity-based" curriculum is not always easy in many South African school contexts where classrooms remain over-crowded and continue to be under-resourced (Umalusi, 2010a, p. 40; see also Clynick & Lee, 2004; Mailula, Laugksch, Aldridge & Fraser, 2003). Indeed, the mismatch between educational policy ideals and the practical realities of their implementation has been widely recognised (Sanders, 2006; Jansen 2011; 2012). Of particular concern is the issue of many under-qualified teachers who are not sufficiently prepared, or capable to deliver such a curriculum effectively (Morrow, 2005/2007a; Simkins et al., 2007; Slonimsky & Shalem, 2004; Surty, 2010; Umalusi, 2010b). Certainly, the (negative) consequences of the implementation of outcomes-based education have been of particular concern of some for a long time (Jansen, 2011; Morrow, 1999/ 2007b).

Clynick and Lee (2004) report that, according to a facilities index, only half of South African schools have the facilities they require to function in the 21st century. Laboratories, computers, libraries, textbooks, and even electricity, running water, toilets and desks in some schools are limited if not non-existent (see also Surty, 2010). These schools routinely under-perform. Furthermore, it has been said that teachers in such schools are trained to improve results, rather than sustain quality teaching (Mabila et al., 2006; Mphahlele, 2010). Jansen (2012) laments the state of teaching in South Africa by describing many teachers as "opting out of education even though their bodies remain in the classroom" (p. 7).

These disadvantaged schools are, almost certainly, all ex-homeland schools or former non-homeland African schools that were administered by the DET (Department of Education and Training). As Zaaiman (1998) explains, it is widely accepted that black African students who attended these schools received an inferior education compared with those who attended the previously White-only (or Indian, or Coloured) schools. In the main part, this situation remains.

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1. To replace the old National Assembly Training & Education Department (NATED) 550 curriculum, the National Curriculum Statement (NCS) was introduced into the General Education and Training (GET) phase in 1998, and into the Further Education and Training phase (FET) including Grades 10, 11 and 12 in 2006, 2007 and 2008 respectively (Reddy, 2006a). The end of 2008 saw all learners in grade 12 write common national exams for the first time (Umalusi, 2009). This common national exam, the National Senior Certificate (NSC) replaced the Senior Certificate (SC). Both these examinations are commonly known as "matric" (this common understanding being rather loosely applied according to Foxcroft and Stumpf, 2005).

Historically, the number of black African children finishing their secondary schooling with a matriculation endorsement[2] has been negligible, and those with a pass in Mathematics (required for entry into science courses) even lower (Clynick & Lee, 2004; Foxcroft & Stumpf, 2005; Kahn, 2006; Reddy & van der Berg, 2006; Simkins et al., 2007) (trends recorded earlier by Hofmeyer & Spence, 1989). Indeed, poor performance in school science and maths is cause for great concern (Bantwini & Reddy, 2009; Clynick & Lee, 2004; DOE, 2001a; Howie & Plomp, 2002; Kahn, 2006; Reddy, 2006b; Reddy & van der Berg, 2006; Soudien, 2007; Simkins et al., 2007), and maths and science teaching and learning in South African schools have come under the spotlight in recent years (e.g. Blaine, 2009).

An example is provided by Howie and Plomp (2002); these authors expressed dismay in finding little difference in mathematical ability between grade eight and twelve learners. Others have reported that, in the days of the NATED 550 curriculum, it was not uncommon for students to have been dissuaded from taking their Senior Certificate (matric) exams in maths and science on Higher Grade (rather than at the less cognitively demanding Standard Grade level) in an attempt to improve pass rates, that some teachers themselves were ill-prepared to handle the Higher Grade subjects, and in some schools these subjects were not offered at Higher Grade at all (Clynick & Lee, 2004; Lolwana, 2006; Rault-Smith, 2006; Taylor, 2009). This compromised students in that, to achieve the Senior Certificate with endorsement, necessary for entrance into tertiary mainstream study, they were required to take at least four of their subjects on Higher Grade[2]. In this respect, mathematics and science subjects have been, and still are, referred to as "gateway subjects" (Kahn, 2006; Naidoo, 2010).

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2. This is the minimum statutory requirement for entry into mainstream study towards a Bachelor's degree. This is granted if a school leaver's curriculum and results are in accordance with prescribed regulations. Prior to 2008 a student obtained a Senior Certificate with matriculation endorsement if their subject groupings and respective levels of cognitive demand, i.e. grade requirements, and results complied with these regulations. The subjects which make up the NCS are offered at one level only, dispensing with the Higher Grade (HG) and Standard Grade (SG) levels formerly used (Vinjevold, 2005). This is now referred to as achieving an NSC that allows admission to a Bachelor's degree (NSC Deg.).

This dearth of students from previously disadvantaged communities entering tertiary science qualifications has severely affected issues of equity, redress and representivity. Since performance in maths and science is part of the developmental indices, and is seen to feed directly into national development and innovation, such performance is a concern at national level both for government and the unions. Consequently, access to, learner performance in, and research into, mathematics, science and technology education has been a priority of the South African education and training system for some time (DOE, 2001a). This is a particularly relevant and pressing issue when considering that South Africa is currently ranked 123 out of 187 countries on the Human Development Index (HDI), a summary measure of human development, a component of which is the education index which measures a country's relative achievement in both adult literacy and combined primary, secondary and tertiary gross enrolment (United Nations Development Programme (UNDP), 2011).

Furthermore, according to the Technology Achievement Index (TAI) (a global index which aims to capture how well a country is creating technological capacity, a component of which is the gross enrolment ratio of tertiary students enrolled in science, mathematics and engineering), South Africa was ranked 39 out of 72 countries worldwide in 2001 (UNDP, 2001). In this study, South Africa's gross tertiary science enrolment ratio was reported to be only 3.4% (i.e. the proportion of the tertiary student population registered in sciences between 1995 and 1997). By 2009, in a follow-up study, South Africa was positioned 55 out of 91 countries (or down 1 position to 40 when only considering the 56 equivalent countries from the original 2001 study), the gross tertiary science enrolment figure having dropped to 3.07% (for 2005-2007) (Nasir, Ali, Shahdin, & Rahman, 2011).

Alternative Access routes into tertiary science degrees in South Africa have become a well recognised option for black African students with academic potential but who do not make Science Faculty entry requirements (Altink, 1987; Downs, 2005; Downs, 2010; Mabila et al., 2006; Parkinson, 2000a; Rollnick, 2006; van der Flier, Thijs & Zaaiman, 2003; Wood & Lithauer, 2005; Zaaiman, 1998). Rollnick (2006) cites Pinto (2001) when claiming that, by 2001, almost every university (including those institutions formerly considered technikons) in South Africa was offering some form of alternative access to disadvantaged students; most of the 41 South African access programmes listed here were/are science based.

Appearing most frequently in the literature, and perhaps to be considered the most well known, are the UNIFY (University of the North) programme, GEPS (the General Entry Programme in Science at the University of Cape Town (UCT), UFP (the Nelson Mandela Metropolitan University Foundation Programme), the College of Science (at University of the Witwatersrand) and the Science Foundation Programme of the University of Natal (Pietermaritzburg) (in latter years, part of the Centre for Science Access of the University of KwaZulu-Natal (UKZN)) (see Kloot et al., 2008; Mabila et al., 2006; Timm, 2005).

Redress and the Centre for Science Access, UKZN

Responsiveness to the needs of individuals and society has become a key theme in university mission statements. The Mission Statement of the University of KwaZulu-Natal reads: “A truly South African university that is academically excellent, innovative in research, critically engaged with society and demographically representative, redressing the disadvantages, inequities and imbalances of the past” (UKZN, 2006a). Within this context, the vision and mission statements of the Centre for Science Access (CSA) were refined and outlined in unpublished Centre reports (see for example CSA School Plan: Progress report 2005).

The vision of the Centre for Science Access was outlined in these School Plan documents as being: “ …(within the context of the University’s vision) to contribute towards a University that will meet the educational needs of all students with academic potential and enable them to play a role in national and regional development and scholarship within the University” (p.3).

The mission statement of the Centre for Science Access was “…to provide educational opportunities for students with academic potential from a disadvantaged educational background thereby contributing to the redress of inequities and imbalances of the past.”

The goals (as outlined in such CSA documents mentioned above) indicate clearly that they have been in line with the declared purposes of the Department of Education’s

White Paper (DOE, 1997a, South African Qualifications Authority (SAQA), 2000), namely to support extended curricula, provide (bridging) and access programmes that will contribute to systemic changes in higher education, and provide special funds for academic development units to ensure quality curricula and improve the success of disadvantaged students. This is clearly acknowledged in the Institutional Audit Portfolio submitted to the Higher Education Quality Committee (HEQC) in 2008 (UKZN, 2008, p.82).

As identified explicitly in the studies by Miller and colleagues (for example. Miller, 1998; Miller & Bradbury, 1999; Miller, Bradbury & Wessels, 1997), the theoretical construct that is embedded in the discourse of academic development, is the principle of academic underpreparedness, or, as Miller, Bradbury and Acutt (2001) frame it, “in its more positive expression, academic potential” (p.147). Relevant to this are discussions by Slonimsky and Shalem (2004) and Steinberg and Slonimsky (2004) on the responsiveness of curriculum development and teaching to the academic, psychological and social epistemic orientations of underprepared students. Extensive work has been conducted in South Africa to explain the nature of underpreparedness of previously disadvantaged students (see Zaaiman, 1998), and indeed, it is because of the dire need to address these inequities, that Access Programmes such as the CSA exist (Downs, 2005; Grayson, 1996; Parkinson, Jackson, Kirkwood & Padayachee, 2007).

In this respect Zaaiman’s (1998) definition of a “disadvantaged student” is useful; “a student can be described as ‘disadvantaged’ if s/he has had inadequate access to quality educational services, resulting in a lack of opportunity to fully develop her/his potential” (p.23). “Disadvantage” thus refers to “educational disadvantage”, which is typically connected to low socio-economic status (as measured by parents’ educational, occupational and economic achievements), second language problems and family breakdown (Zaaiman, 1998). Less distinct is the issue of rurality coupled by Zaaiman (1998) with disadvantage (although it may be noted that the majority of the CSA students, particularly on the Pietermaritzburg campus, have come from rural areas) (Faculty Officer for Science Access, personal communication, March, 2009).

Although, as Zaaiman (1998) points out, it will become increasingly inaccurate in South Africa to simply equate “being black” with “being disadvantaged” (p. 30), the large majority of students for whom these Access programmes have catered, have been black African.

Foundation Programmes in particular have been at the forefront of educational change in South Africa. Defined by Kloot et al. (2008) as “special programmes for students whose prior learning has been adversely affected by educational or social inequalities” (p.800), these authors report that the Foundation Programme of the CSA has been “widely regarded as an outstanding effort in the genre of foundation programmes (p. 806)”.

The Centre for Science Access: Personal Context

As a Life Science graduate of the University of Natal, Pietermaritzburg myself, I have had a long association with the CSA at UKZN. I was employed as a student demonstrator for the progenitor of the CSA, the Science Foundation Programme (SFP) in the early 1990s, worked as a research assistant in the Programme for a short time in 2000, and returned as a full-time, permanent staff member at the beginning of 2002. I held the position of Foundation Biology coordinator and lecturer until the end of 2011 when I resigned to enable me to focus on this retrospective synthesis of my research journey. My personal departure from UKZN and the CSA coincided with a major restructuring of the College of Science[3] that saw an end to the Centre for Science Access in the form in which it is described in this research. At the beginning of 2012 when I put forward a proposal to compile this synopsis of my research towards the completion of a PhD degree, the University’s plans for Science Access (in the face of new College structures and systems) were unclear. It is hoped that this study may be of value towards this end.

It is without doubt that I have had a vested interest in the Science Access Programmes at UKZN as they existed up to the end of 2011, and the success of students that have passed through them. Once I have laid out my research philosophy in the next chapter however, I hope that it will be clear that my vested interest can, in no way, be construed as bias.

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[3] With the restructuring of UKZN Colleges, as from the beginning of 2012 the Faculty of Science and Agriculture is referred to as the College of Agriculture, Engineering and Science. For the purposes of the current research, the term Science Faculty is used throughout since this was the relevant structure at the time the data were collected and analysed.

The Centre for Science Access: A Brief History

Given the plethora of socio-political and economic deficiencies in South African Education, and the paucity of black African graduates, the Science Foundation Programme (SFP) was launched in 1991 on the Pietermaritzburg campus of the University of Natal (UN), six years before the Department of Education's White Paper, in an attempt to furnish a selected number of Department of Education and Training (DET) matriculants with the skills, resources and self confidence needed to embark on their tertiary studies (Grayson, 1993; 1996). According to the original Template for Internal Approval of Programmes at the University of Natal (Programme Template, 1999), the purpose of the SFP was "to provide a programme of foundational and other relevant courses for previously disadvantaged students who do not meet the formal entrance requirements of the Faculties of Science and Agriculture (Pietermaritzburg), Science (Durban), Engineering and Medicine but who are judged to have the potential to succeed in those faculties, thereby allowing them to enter degree programmes in those faculties".

On the Durban campus of UN a four-year Bachelor of Science (BSc) curriculum in which students were admitted directly into first-year courses was also in operation by 1991 (Parkinson, 2000a); this has always been referred to as the 'Augmented Programme.'

Similarly, from 1999 the University of Durban Westville (UDW) operated its own Science Foundation Programme which was quite different from that of UNP. The merger between UN and UDW into the University of KwaZulu-Natal (UKZN) in 2004 saw the amalgamation of the alternative access programmes and the Centre for Science Access (CSA) was formed. The CSA was built upon the premise that students, admitted to alternative programmes are all from a disadvantaged educational backgrounds, but are not a homogeneous group in terms of academic preparedness (Centre for Science Access, 2005). Consequently, the CSA has offered two programmes: a Foundation and an Augmented Programme under the umbrella of a consolidated unit that has operated as a cross-campus centre. From the time of the merger, the Foundation Programme stretched across both the Pietermaritzburg and Westville campuses, following the model of the original SFP of UN in terms of educational philosophy, resources and curriculum (Centre for Science Access, 2004; see Appendix 1 of this report). The Augmented Programme moved in 2006 to the Westville campus from Howard College (Durban), and in 2007 was instituted on the Pietermaritzburg campus of UKZN as well.

The CSA operated as a physical unit until, at the end of 2011, a major restructuring of the College of Science resulted in it being subsumed by the Centre for Academic Development and Monitoring. From the beginning of 2012, the CSA has taken on the existence of a virtual centre, the modules of the Foundation and Augmented Programmes (and the staff who teach on them) being absorbed into their respective Schools. The College of Science continues to offer the Programmes to students, but this devolvement of the composite modules to different Schools has effectively terminated the existence of the CSA as it is described below, and as it operated until the end of 2011. This has obvious implications for the form Science Access will take at UKZN in the future.

Implications of funding for structure. In 2006 the National Department of Education issued directions for funding frameworks for foundational provision in educational programmes (DOE, 2006a). This was in context of National Higher Education policy changes to a programmes- and outcomes-based system where academic planning is done as much from the perspective of the student as from a disciplinary perspective (Breier, 2001; Ensor, 2002; Higher Education Quality Committee (HEQC), 2004; Luckett, 1998; SAQA, 2000). According to the National Commission on Higher Education (NCHE, 1996) (cited by Ensor, 2002), a programme should consist of a “coherent, planned and integrated sequence of learning activities, successful completion of which leads to the award of a formal qualification at certificate, diploma or degree level” (p.280). The Higher Education Quality Committee of the Council on Higher Education (2004) also describes a programme as a purposeful and structured set of learning experiences that leads to a qualification. This latter definition was used by the Department of Education (2006) when outlining the funding of programmes. Since national policy does not provide for foundational qualifications, the term “foundation programme” does not agree with the formal definition of a programme, thus excluding such foundation programmes from the government’s funding policies. From 2006, only “extended curriculum programmes” that offered “foundational provision” would be accommodated by national funding (DOE, 2006a).

The merged CSA Foundation Programme has certainly always reflected many of the characteristics of a “programme” as described in these policy documents. Following the definitions of Breier (2001) and Luckett (1998), it has been a coherent combination of units of learning modules expressed in an outcomes-based format. Furthermore, 'programmes" are considered as "vehicles" for improving access to higher education by South Africa's poor and previously disadvantaged, aimed at providing lifelong learning, and focussed on student-based learning rather than subject based teaching (as described by Ensor, 2002, p. 278). All these characteristics have been inherent in the Foundation Programme of the CSA as described by the School Plan (CSA, 2004; 2005), which has reflected the philosophy of the original SFP (see for example Grayson, 1997; Programme Template, 1999). However, the completion of the year-long Foundation Programme has never lead to its students receiving a qualification. Thus, according to formal definitions, the Foundation Programme could not be called a "programme". This clearly has had implications for funding from government and consequently the structure of the CSA.

To accommodate Government's funding policies, from 2007 the CSA programmes were redefined. The 'Augmented Programme', being integrated into first year already, automatically qualified for funding; this programme formally became known as the augmented stream of the Extended Curriculum Programme, i.e. BSc4 (Augmented). Those students who left school with a matriculation endorsement (with the implementation of the National Senior Certificate, this is referred to as meeting the requirements for entry to a Bachelor's degree), but who did not qualify for the augmented stream, entered the foundation stream of the Extended Curriculum Programme (BSc4 Foundation). These students, if they passed their foundation year, carried 32 credits into their degree thus fulfilling the "credit exchange" criterion of a "programme" as described by Ensor (2002, p. 275). From 2012, these streams continue to be offered to applicants with these entry qualifications but without the CSA acting as a unifying body.

The augmented and foundation streams of the extended curriculum have always earned very similar subsidies from the government; for example in 2010 the latter earned UKZN only a few hundred rand more per student in subsidy than the former (Division of Management Information, UKZN, 2010). These subsidies are calculated on teaching input (weighted full time equivalents based on module enrolments) and teaching output (weighted fractional graduates calculated on student throughput).

Those students without a full matriculation endorsement entered what continued to be called the Science Foundation Programme (SFP); these students carried no credits into their degrees and attracted no government subsidy. Although they were registered differently, these students followed the same curriculum, and attended the same classes, as those registered for the BSc4 Foundation stream. For the purposes of this research, and as has colloquially been the practice in the CSA, the two foundation streams (the SFP and the BSc4 Programme (Foundation stream) are referred to as foundation students in the Foundation Programme. From 2012, students who would historically have been enrolled in the Science Foundation Programme will not be given access to the University since this route is longer offered by UKZN (Faculty of Science and Agriculture Handbook, 2012). Figure 1 illustrates the various streams of the CSA until the end of 2011.

Notably, the Foundation and Augmented Programmes have **not** been bridging courses, designed to “fill in the gaps left by inadequate schooling” as described by Kloot et al. (2008, p. 801). As these authors point out, bridging programmes have been considered to provide “academic support” as opposed to the “academic development” of ‘foundation programmes’ (read ‘foundational provision in an extended curriculum programme’ according to the DOE (2006a) definition). A central tenet of ‘foundation programmes’ (ibid.) in general is that the disadvantaged students in such a programme need more *time* and more *tuition* in laying the foundation for their mainstream studies (Kloot et al., 2008). These authors claim that the (original) SFP was much more than this, describing it as an “holistic model” (p. 805); one may be inclined to assume that the merged Foundation Programme of the CSA could lay claim to this too, considering that it, until the end of 2011, it had changed in name only.

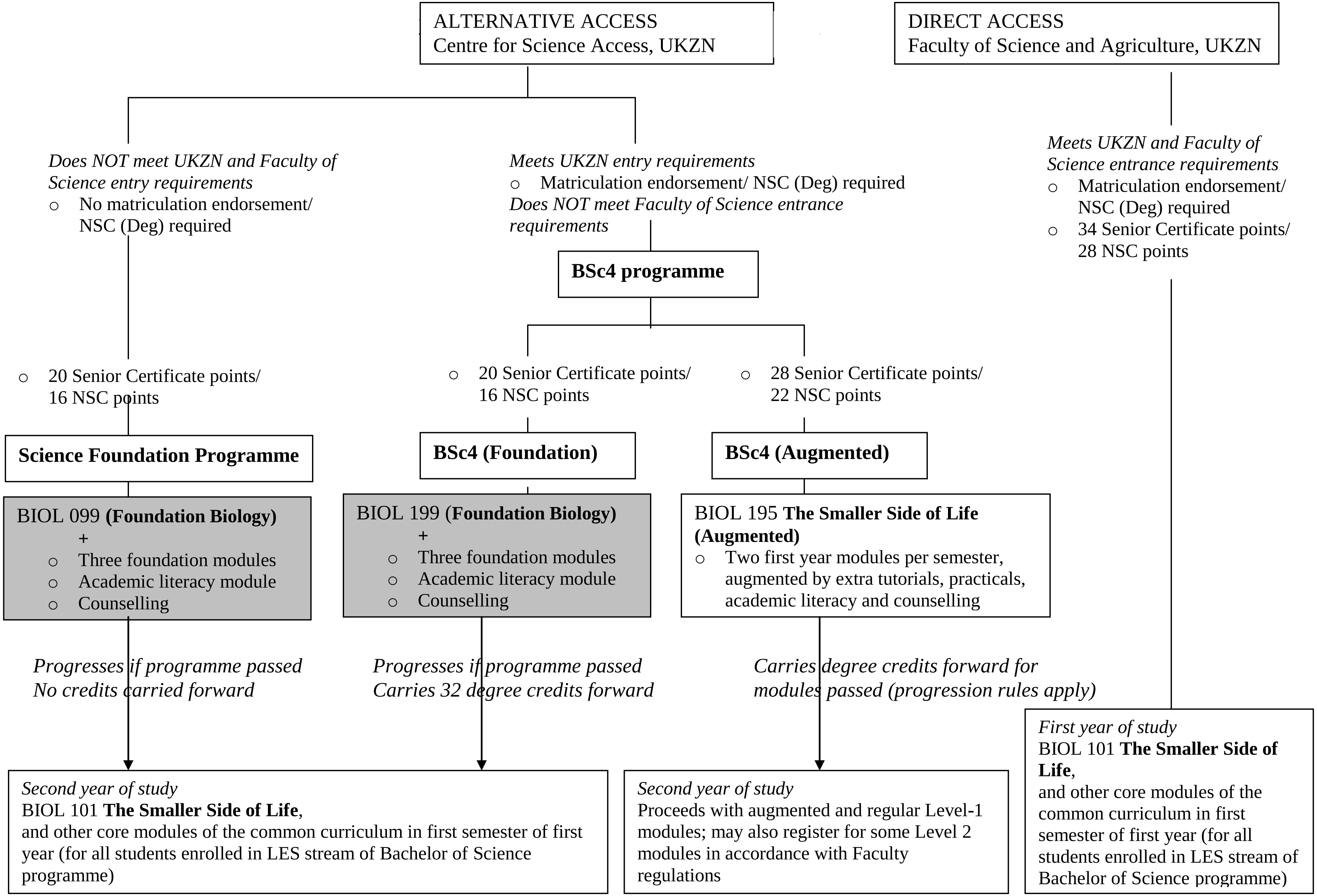

Figure 1. The Centre for Science Access streams in context of the Faculty of Science and Agriculture, UKZN. The two shaded streams have been collectively known as the Foundation Programme.

Implications of funding for autonomy and accountability. The CSA has historically enjoyed a fair amount of autonomy with respect to student admissions, curriculum, methods of teaching and assessment. This has been particularly true of the Foundation Programme since, as will be more fully explained later, it has stood apart from the Science Faculty's mainstream first year. Despite this functional autonomy, the CSA has been fully integrated into faculty structures, with a Science Access Board and Executive Committee (UKZN, 2008). The establishment of academic regulations and the internal management of financial resources generated from private and public sources have been regulated by these committees which have reported to the Science Faculty Dean. Periodic reviews (mediated by the University's Quality Promotion Unit) have required the Centre to account for its philosophy, curriculum, actions and decisions, and student performance, to the institutional community (Southway-Ajulu, 2005; 2007), and also to broader society, including the private donors from whose generous funding the Centre has also benefited.

In latter years, the Centre's academic regulations and resource management has become increasingly determined by the DOE's funding policies and the concomitant restructuring of the Centre's programmes (described above). Government funding of the programmes has meant progressively closer scrutiny of student throughput and graduate success by the Faculty (which has been, and continues to be accountable to the Government) over the years, and particularly since the merger in 2004. On the basis of student enrolment and throughput, government funding has been either extended or withdrawn. Indeed, institutional autonomy is inextricably linked to the demands of public accountability (DOE, 1997a); "Public accountability requires that institutions receiving public funds should be able to report how, and how well, money has been spent (and)… demonstrate the results they have achieved with the resources at their disposal (and)…how they have met national policy goals and priorities" (DOE, section 1.25, 1997a).

In addition to the funding that the University receives from National Government in the form of subsidies mentioned earlier, the CSA has received an additional foundational grant from the National Department of Education. Despite this apparent availability of sufficient funding for the Centre (see also UKZNa, 2008, p. 83), and the acknowledgement that the two extended curricula cater for entrants with different "knowledge bases" (ibid, p.82), inevitably, questions have been asked about the efficiency of having two alternative Access routes into the Science Faculty of UKZN (now the College of Science). This was a key issue debated at an Access workshop held by the UKZN Teaching and Learning Office in May of 2009, the purpose of which was to "critically review all access programmes and policies at UKZN, share innovative practices to continuously improve and develop such programmes, discuss challenges and plan for access initiatives over the following five years" (University of KwaZulu-Natal Teaching and Learning Office (UTLO), 2009).

Indeed, it has been acknowledged that the model of small group teaching within a comprehensive supportive infrastructure such as has been offered by both the foundation and augmented models of the CSA (now the BSc4 Programme) is resource intensive (see below; UKZN, 2008). On the other hand, the foundation and augmented students registered for the extended-four-year curricula attract similar government subsidies per head. Thus there appears to be little to distinguish the cost of the foundation model from the augmented model. However, this is not so when one considers that for half of their first-year curriculum, the augmented student attends regular, predominantly unsupported, mainstream contact sessions in large classes taught by tenured staff already in departments (Downs, 2010; Parkinson, 2000a). Perhaps even more importantly, these augmented students are able to remain in the University system for longer, even if they fail some of their modules (see progression rules in the Faculty of Science and Agriculture handbook, for example, 2010). These students thus attract funding for longer as they are not removed immediately from the system if they underperform. This is not the case for Foundation Programme students who, unless they pass all of their five requisite modules in their access year, are excluded from the Science Faculty (College) of UKZN before entering mainstream. Those who have been lost to the Faculty of Science and Agriculture have very often been recommended to other Faculties within the University, to a University of Technology or to a Further Education and Training (FET) facility. However, because of their weak entrance qualifications that placed them in the Foundation stream in the first place, it has been unlikely that they would have been admitted to any other university science faculty. Indeed, records show that only a proportion of Foundation Programme students have passed their access year (Table 1, see also Downs, 2010).

The questions about the cost effectiveness of the dual science access programmes at UKZN, and a desire to gain a better understanding of the relative successes of the foundation and augmented models in meeting the local and national objectives of redress outlined above, and in extending access to science in particular, must surely underlie the call made for critical review mentioned above. This research is intended as a contribution to a wider response to this call. Specifically, given my personal context as a lecturer of Foundation Biology in the Foundation Programme of the CSA when I began this research, and as appropriate for grounded theory studies (see Chapter 3), I started out by wanting to review the performance of Foundation students in a mainstream Biology module for which their access year is intended to prepare them. Furthermore, in exploring the relative contribution of various impacts on the success of students in such an access programme, opportunities may be found for remediation towards improved future successes in meeting these objectives.

These goals are laid out in context of the national, and indeed international, priorities towards building capacity in the sciences.

Table 1

Number of Students Proceeding from the Foundation Programme (2006-2009)

Year	Original intake	Attrition from Programme *	Number of students proceeding from Programme
2009	109	64	45
2008	87	42	45
2007	66	41	25
2006	97	62	35

Note. * Attrition includes a few (around one to three) students who withdraw each year for a variety of personal reasons, the balance are academically excluded either in June or November. Results reflect proceed-rates after supplementary exams results released.

Access to the CSA

Students have been, and continue to be, accepted into the CSA programmes only if they have come from disadvantaged schools. These are schools that fall into quintiles 1 to 4 according to the Department of Education “poverty index” based on the physical condition of schools and the poverty of the surrounding community (DOE, 2003; DOE, 2006b; DOE, 2009a). The index is used for resource targeting purposes (where National Quintile 1 is the poorest and National Quintile 5 is the least poor school); NQ1 and NQ2 are no-fee schools. Students from quintile 5 schools are usually not considered for access programmes.

Aside from the “disadvantaged” criterion, various additional stipulations and minimum criteria have been applied over the years as the Centre has grown and contextual factors have changed. There has never been a racial criterion for selection into the Foundation Programme, although the majority of students have tended to be black African with far fewer Indian and Coloured students registering. A racial criterion has been applied for acceptance into the Augmented Programme however, with 5% of the available spaces reserved for Indian, Coloured or White students.

At the time of inception of the SFP (as explained above, one facet of the merged CSA), students were selected annually on the basis of their performance during a 12-day on-campus selection programme during which mini-courses in Biology, Mathematics Chemistry and Physics were held. An attempt was made to measure the learning potential of each student by assessing their “zones of proximal development” as described by Vygotsky (1978) (cited by Grayson, 1996). Thus the improvement that students showed in post-test results after instruction was used as an indication of academic potential. Later, due to financial constraints and rising numbers of applicants, this selection procedure was shortened to the administration of in-house selection tests without the intervening instruction. For some time, performance in these tests was used in conjunction with matric results to select students (then only SFP), and although a matriculation endorsement was not required, the selection policy dictated that students did need at least a Senior Certificate including Mathematics, Physical Science and/or Biology or Agricultural Science (Chetty, 2005). These selection tests have undergone continuous and rigorous investigation over the past ten years and have evolved considerably over this time (Grussendorf, Liebenberg & Houston, 2004). Indeed, the Mathematics and Science selection tests used to select the 2010 cohort did not much resemble the original ones. As a consequence of the findings by this researcher, only the maths selection tests were used to select the 2011 students (recorded in Chapters 9 and 10). Selection tests have not been used to enlist the 2012 student intake (Yvette Chetty, personal communication, November, 2011).

These tests have only ever been used to select students into the Foundation Programme. Only a proportion of those students who have applied to the Programme have been invited to sit these selection tests; a small minority of those who have written the tests have been offered places. For example in 2009, 1161 students applied for the Access Foundation streams, 63% of whom met the minimum criteria and wrote the tests. Only 23% of those who wrote the tests met the selection test criteria. In other words, 14% of students who applied to the Programme were offered places (Yvette Chetty, CSA Selection Officer, personal communication, March, 2009). Furthermore, a number of students offered places have not entered the Programme for various reasons (for example financial or personal).

Students applying to the Augmented Programme have not needed to sit selection tests, and as long as they have come from disadvantaged schools and met the minimum requirements (Tables 2 and 3), they have been considered for the programme (see Admissions policy in UKZN, 2006b).

An in-house language test has also been used in the past to select foundation students, but this has in recent years been replaced by the Standardised Assessment Test for Access and Placement (SATAP) - English for Academic Purposes Test and has been used for placement into the different academic literacy modules that Access students have been, and still are, obliged to take, rather than for selection (Parkinson, 2005).

Minimum criteria for selection into the Faculty of Science and Agriculture at UKZN[3] prior to the implementation of the National Senior Certificate (NSC) in 2008 are given in Table 2 (these were for the Senior Certificate). Table 3 provides minimum criteria for entry into the Faculty from 2009, where levels of performance (on a scale of 1 to 7) replaced the use of symbols on higher grade (HG) or standard grade (SG). It must be borne in mind that these school results have been used in conjunction with the selection tests to select the Foundation Programme students. Appendices A and B describe the values of the symbols and levels of performance respectively, and the calculations for the Admission Points Score (APS), a composite score, also used for admission. The transition in 2008 from the Senior Certificate to the NSC has required some normalisation. Umalusi (the South African Council for Quality Assurance in General and Further Education and Training) has developed a statistical model, as part of their Maintaining Standards Project, that allows for moderation and comparison across the two curricula and examinations (the old Senior Certificate and the new NSC), and which was used in constructing "guideline norms" (Naidoo, 2010, no page no.). Appendix C indicates this statistical model.

Table 2

Minimum Criteria for Selection into the Faculty of Science and Agriculture, UKZN (2006-08)

Student group	Senior Certificate (matric) level (minimum)			
	Endorsement required	APS	Maths	Science *
Foundation Programme				
SFP	None	20	SG F	SG F
BSc4 Foundation stream	Full	20	SG F	SG F
Augmented Programme (BSc4 Augmented stream)	Full	28	HG E *or* SG B	HG E *or* SG B
Direct Entry **	Full	34	HG E *or* SG B	HG E *or* SG B

Notes. Criteria given as laid out in the Faculty of Science and Agriculture, UKZN handbooks for respective years. SG = Standard Grade, HG = Higher Grade.

*Science subject may be either Biology, Physical Science or Agricultural Science

** For entry into the general BSc Life and Earth Sciences (LES) undergraduate degree

Table 3

Minimum Criteria for Selection into the Faculty of Science and Agriculture, UKZN from 2009

Student group	National Senior Certificate (NSC) (minimum)				
	Admission to Bachelor's degree	APS	English *	Maths	Science **
Foundation Programme					
SFP	No- NSC	16	Level 4	Level 2	Level 2
BSc4 Foundation stream	Yes NSC (Deg)	16	Level 4	Level 2	Level 2
BSc4 Augmented stream	Yes NSC (Deg)	22	Level 4	Level 3	Level 3
Direct Entry ***	Yes NSC (Deg)	28	Level 4	Level 4	Level 4

Notes. Criteria given as laid out in the Faculty of Science and Agriculture, UKZN handbooks for 2009/2010 and 2011 and the Admissions Policy in UKZN (2006b). For those students who matriculated before 2008, criteria in Table 2 apply.

* Also required for Life Orientation

**Science subject may be either Life Science (Biology), Physical Science or Agricultural Science

***For entry into the general BSc LES undergraduate degree

The CSA Programmes: A More Detailed Description

Note: From 2012, the programmes of the CSA continue to be offered to applicants with the entry qualifications described above, but without the Centre acting as a unifying body (and, as already noted, with the exception of the Science Foundation Programme stream which is no longer offered). Students will thus register for the respective modules described here, as offered by different Schools within the College of Science.

The Augmented programme. The augmented stream of the four-year BSc degree programme (known as the Augmented Programme) involves students registering for half the number of modules in their first year than the direct entry first-year student (see for example, Faculty of Science and Agriculture Handbook, 2011). This reduced load of ordinary first-year courses is augmented by additional lectures, practical sessions and small group tutorials (usually of about 30 students). In effect, the augmented students experience twice as many contact sessions as regular mainstream students for the two augmented courses taken. Typically, course combinations taken are Mathematics and Physics or Chemistry, Physics and Chemistry or, for a student wanting to pursue Life Sciences, Chemistry and Biology. All augmented modules are one semester long, requiring students to complete two in each discipline in their first year on campus. For example, a student augmenting Biology and Chemistry in their first year would need to take BIOL 195 (which incorporates mainstream BIOL 101) and CHEM 195 (ditto) in semester one, and BIOL 196 (incorporates mainstream BIOL 102) and CHEM 196 (ditto) in the second semester (see Appendix D as an example). All of these augmented modules bear credits towards achieving a bachelor's degree.

For the mainstream component, students attend lectures and practicals with regular mainstream students; in the additional tutorials and practicals augmented staff address problems with the mainstream lecture material, as well as dealing with foundational material. The small group situation offers opportunities for direct contact with staff and individual attention, allowing confidence to be built. Classes are interactive and generic skills such as reasoning and problem solving are learnt with emphasis also being placed on practical skills in the augmented laboratory sessions. These features are absent in mainstream classes which are typically very large and remote from teaching staff. Indeed, as Parkinson (2000a) has pointed out, the Augmented Programme has always sought to develop productive learning strategies in students, autonomy, and a sense of responsibility for their own learning.

In his/her second year, depending on the performance of the student, and the number of foundation and degree credits achieved in their first year, a student may register for other first-year modules that may be augmented or not, as well as some second year courses. Thus rather than being a degree in which students take two years to do first year, the Augmented stream curriculum is closer to a degree in which students take three years to do the first two years of a three-year degree (CSA report, 2004; Faculty of Science and Agriculture Handbook, 2011; Parkinson, 2000a).

All augmented students are obliged to complete modules in academic literacy and attend counselling sessions in their first year at university (see below).

The Foundation Programme. Foundation students enrol in a stand-alone composite curriculum consisting of compulsory, year-long foundation Mathematics, Physics, Chemistry and Biology modules. Like the augmented students they also have to complete an academic literacy module. This and a counselling component are integrated into the timetable of the foundation “package”. There are no elective modules. The subjects have always run concurrently throughout the year to maximise the opportunities for transfer of knowledge between the subjects. Appendix E gives details of each module as they appear in the Science and Agriculture Faculty Handbook (e.g. 2010; 2011).

The Foundation Programme curriculum has differed from a bridging programme in that it has not assumed that the students enter at a level close to what is needed for entrance into the University environment, but has assumed that students need to build a foundation for meaningful learning, in many cases for the first time. Students have not been pre-taught for their undergraduate degree as the intention is for them to acquire flexible, transferable learning strategies and appropriate study habits rather than familiarise themselves with content from first-year courses. This foundation has been built in a phased manner, where the beginning and end of the programme have been matched to where the students come from (first semester) and where they wish to go next (second semester, and subsequently into the University mainstream) (CSA, 2005; Grayson, 1996). This transition has been phased in terms of pace of work, quantity of work, scaffolding required and level of difficulty, the intention being that students are able to operate in their (Vygotskian) zone of proximal development.

The broad integration of disciplines has been an important aspect of the Foundation Programme curriculum; a demonstration of the unity (and diversity) of science to students has thus been made possible. Transfer of learning from one context to another has been made possible by the mutual development of the curriculum by an inter-disciplinary team and also by the continuous discussion amongst members of the staff from each discipline about transfer opportunities. Indeed, Trowler (2008) from interviewing the CSA staff on the Pietermaritzburg campus, has acknowledged the Foundation Programme staff as a fine example of a community of practice. Certainly this has had value for effectively delivering a curriculum that the Foundation Programme has aspired to do. The devolvement of the composite modules to the separate Schools from 2012 obviously has implications for this practice that has been in place until recently.

Academic literacy. For the majority of Access students, English is a second language. At UKZN English is the medium of instruction. Consequently, students who come from disadvantaged educational backgrounds are further disadvantaged when they arrive at university since they have had limited exposure to academic texts and little opportunity for extended writing (in English), since neither of these is practised much in their poorly resourced schools (Parkinson et al., 2007). These authors refer to their school experiences being "characterised by subtractive bilingualism" (p. 444). Both conceptual understanding and reading and writing skills have not been adequately developed in the mother tongue before the medium of instruction switches to English early in a student's primary schooling (see also Inglis et al., 2007). Consequently, pupils do not have the opportunity to transfer their Cognitive Academic Language Proficiency (CALP) into English; they have to develop these skills whilst learning an unfamiliar, second language (Parkinson et al., 2007; 2008). Furthermore, there is a poor culture of reading amongst these students with even reading for pleasure being unusual as reading in English is often laborious and appropriate texts in African languages rarely available (Parkinson et al., 2007). Students are therefore unprepared for the literacy demands made on them by University modules, in particular extended science texts which English Second Language (ESL) students find lexically dense, and therefore difficult to process and produce (Jackson, Meyer & Parkinson, 2006). Indeed, students battle not only with technical words, but also with general academic words, words usually considered “everyday” words, and idiomatic language (Parkinson et al., 2007). In spite of their poor CALP, they are often proficient in basic interpersonal communication in English, albeit Black South African English rather than Standard English (Parkinson et al., 2007).

Consequently, it has been, and remains, compulsory for all Science Access students to register for an academic literacy course where their English reading and writing skills are scaffolded and they are given exposure and experience with academic texts. They are genre-based courses grounded in level 1 science content, and introduce students to the “major modes of writing and speaking that will be required of them in their science degrees: synthesis of literature (essay writing), report writing (involving analysis of data), posters and short oral presentations” (Parkinson, 2000a, p. 215).

Students are streamed into either the Communication in Science or Scientific Writing and Reporting modules (Appendix F) on the basis of results of the Standardised Assessment Test for Access and Placement (SATAP) English for Academic Purposes Test. Those achieving weaker test scores register for the Communication in Science module. These modules are open to all students in the faculty, but are not compulsory for regular mainstream students. They are accredited modules for augmented and BSc4 Foundation stream students, although the SFP students have not received accreditation (in spite of such a module having been compulsory for them too).

The counselling component of the Access Programmes. Once at university many Access students are overwhelmed by the financial, social and academic demands placed on them by university life. These stresses, compounded by high family and/or community expectations often cause anxiety (Barnsley, 2002; Barnsley & Liebenberg, 2000a). In addition, students commonly have to deal with trauma such as death in the family or problems associated with HIV and AIDS which affects their academic performance (Barnsley, 2002; Barnsley & Liebenberg, 2000a). Some students also have a range of trying practical issues to deal with such as lack of accommodation and transport problems (Barnsley, 2008a). Behavioural problems include a lack of time management skills, failure to realise the importance of preparation or completion of homework and failure to seek help when needed (or conversely becoming too dependent on a staff member) (Barnsley & Liebenberg, 2000a; Grayson, 1996; Parkinson, 2000a).

In order to help with such adversities, and to provide for other personal and social needs, it has been compulsory for all Access students to attend counselling sessions, both timetabled for the different Programmes, and on an individual basis. During the formal timetabled contact sessions, students have been taught life skills, community awareness and given career guidance. Indeed, research has shown that positive, available career advice can promote student persistence during their first year at university (Tinto, 2005). A comprehensive wellness programme has also included individual counselling, small group coaching, training and mentoring and academic monitoring (Barnsley, 2008a).

The counselling component has therefore played a very important role in supporting students as they make the adjustment to university, and is crucial if they are to persist in their studies (Tinto, 1998; 2005).

The structural approach of the Access Programmes has thus been in line with the findings of Gilbert and Lovegrove (1972) who realised long ago that:

> The psychological and sociological needs of African children require primary science courses to have more comprehensive aims than those limited to the learning of a miscellany of scientific information; they should be as much concerned with the development of attitudes, the acquisition of skills and an elementary but secure understanding of cause and effect as with gaining knowledge (cited by Grayson, 1996, p. 995).

Accountability: Measures of Success of the Foundation Programme to Date

Student performance once students have “qualified” from the Foundation Programme has been tracked in two reports by Southway-Ajulu (2005, for graduation rates from the inception of the Programme up until 2004, and 2007, for performance between 2003 and 2006). In this latter report, it was reported that students admitted through the Faculty’s Science Access initiatives had made a significant contribution to the number of graduates in the years studied. In addition, Parkinson and colleagues (2007) have shown that the intervention of the Communication in Science module has improved the Science Access students’ performance in an English proficiency test.

However, an evaluation of Foundation Programme student performance in a mainstream biology module between 1995 and 2000 was not encouraging (Downs, 2005), with students performing particularly poorly in the theoretical component of both the Foundation and first-year examinations and course work. Conditions had changed considerably by the time I started conducting the research that is reflected in this study (2008), and indeed, the module continued to evolve reflexively in subsequent years.

Amongst other factors, the student and staff bodies had changed by 2008, the first-year modules were different in a number of respects (e.g. curricular content and assessment), and the Foundation Biology module, although standing by its original philosophical and pedagogical principles, had undergone revision in terms of curricular content. As has been suggested, conditions and circumstances continue to be fluid. Subsequent to her 2005 study, Downs (2010) did a detailed analysis of the contribution made by the Foundation Programme on the Pietermaritzburg campus of UKZN, to increasing the number and quality of black African graduates. The progress made by (original) Science Foundation Programme cohorts for the years 1991-2003 up to the beginning of 2006 was analysed. Overall, of the 1533 students that had enrolled in the Programme at Pietermaritzburg campus during these years, 72% had subsequently registered for tertiary study at UKZN (students that registered elsewhere were excluded from the study). Most of these students had matriculation points below that required for direct admission to the science faculties and all were from disadvantaged backgrounds. Of those that registered for degree programmes, 43% had graduated with another 25% in progress. Nearly 80% of those graduated were from the science faculties (Science and Agriculture, Medicine or Engineering). Of the students that had graduated, half (51%) had continued with postgraduate study. This study concludes that, whilst also appearing to be an effective system for selection into mainstream, the Programme has significantly increased the quantity and quality of science graduates in South Africa and highlights the valuable role played by such a Programme in issues of access and redress. Furthermore, the study shows that the SFP has been influential in increasing Black female participation in the sciences, a contribution, the study concludes, that indirectly empowers communities and the nation.

As is thus apparent, measures of success for Foundation students have been conducted several times in the past. Not only it is necessary to continually evaluate performance of the Foundation Programme, but more research could be conducted on the performance of the BSc4 Augmeted students once they have completed their initial year at university. A further study that examines the retention rate and number of years students require to successfully graduate would also provide more insight into the relative success of the alternative access options.

A Theoretical Framework for Curriculum Development in the Foundation Programme

Gaining insight into the factors[4] affecting performance of the Foundation Programme students offers opportunities for understanding the "challenges" in the UKZN Access Programmes and opens up the way for "continuously improving and developing such programmes" as was called for in the 2009 Access Workshop held by the UTLO as mentioned earlier.

Curriculum development, certainly in the Foundation Biology module, has occurred within a constructivist framework[5]. This aims to create or improve the classroom environment so that it best "provides the social setting for mutual support of knowledge construction" (Driver, 1988, p. 138). This will require cognisance to be taken of what the learner already knows as this will form the basis for the construction of further knowledge (Driver, Asoko, Leach, Mortimer & Scott, 1994; 2004; Duit, Treagust & Mansfield, 1996; Hewson, 1996) as well as an examination of the learning tasks set, the students' interpretations of these tasks, and the kinds of interaction between the staff and learners (and between learners). Reflection by staff on their teaching and research experiences during the year, and feedback from the learners, allows for further development of the modules, and in this way curriculum development cannot be separated from teaching staff development.

The original Science Foundation Programme was establishing itself at the same time the University of Natal as an institution was preparing itself for curriculum reform (Luckett, 1995). At the time, Luckett (1995) argued for curriculum development that was situated within the hermeneutic paradigm, whilst being conscious of the possibility that, in meeting the need to widen access given the demand for greater equity and the massification of higher education, curriculum reform might have been pushed in a more traditional direction. Whilst curriculum development in the Foundation Programme has been predominantly hermeneutic, there indeed has also been a fair measure of traditionalism.

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[4] The word "factor" where employed in this text is used in the sense that is described in the Concise Oxford Dictionary (Soanes & Stevenson, 2004) as "n. a circumstance…contributing to a result". It is intended to convey the same meaning as "variable" as described by Field (2009) as "just a thing that can change" (p.7) and not as a synonym for "independent variable", a term commonly associated with controlled experimental design (Field, 2009, p.786)

[5] Since the author no longer assumes responsibility for the coordination and teaching of the Foundation Biology modules, what is recorded in this research refers to the status quo at the end of 2011.

For instance, the traditionalist notions of setting predefined learning outcomes, and having an understanding of what kind of learning we wish our students to achieve, has been integral to a programme that is preparing students for a particular purpose, i.e. mainstream University education. This has been, and continues to be, particularly pertinent in the Foundation Programme where a much higher risk is taken when accepting students from academically disadvantaged backgrounds and whose entrance criteria are far below those entering mainstream. The Foundation Programme has been shown, after all, to be an effective selection device itself for entry into mainstream (see Table 1 and also Downs, 2010). In this sense, there is a certain “output” that is required of the Programme - a student’s performance must be measurable against some original objective, so as to ascertain readiness for the formal University environment.

Grundy (1987, Chapter 1) describes this more positivist approach, based on Habermas’ “technical interest”, as “rule following action based upon empirically grounded laws” (p. 12) where judgment is made on effectiveness and efficiency.

In addition, there has existed (certainly in more recent times) a financially motivated pressure on modules to produce pass rates that are “acceptable” to the University and to National Government. It is this aspect of traditionalism that Luckett (1995) warned against when considering curriculum reform at the University of Natal (and thereafter at UKZN); indeed, as alluded to earlier in this chapter, this exists more so than ever before. The challenge remains then how to engage in hermeneutic curriculum development, educate a student to be a lifelong learner with constructivist skills and resources whilst simultaneously producing an acceptable pass rate. This challenge is even greater in access programmes whose students hail from traditionalist schools where the reality is, in spite of national policy reform, that curriculum is still viewed as a product and content based teaching and learning prevail.

To ensure readiness for mainstream, and before selecting their chosen fields of specialisation, it is inevitable that the foundation in science that students develop in the Foundation Programme has, to some extent, a disciplinary orientation as described by Ensor (2002). This disciplinary orientation is also traditional, an approach promoted by those who argue that education should be an apprenticeship in the “ways of knowing”: of modes of analysis, of critique and of knowledge production. This has reference with mode 1 knowledge production as described by Gibbons (1994) cited by Breier (2001).

However, it is the interdisciplinary nature, and learning of generic, transferable skills and knowledge of the Foundation Programme that has, to date, been primary. The development of generic skills (for example written, oral and interpersonal communication skills, and problem solving) is regarded as a key element of lifelong learning (see Breier, 2001). The strength of this Mode 2 (see Kraak, 2000) knowledge depends on the disciplinary expertise that is produced in Mode 1 (Bawa, 1997 cited in Breier, 2001). Acknowledging the relevance and place of both Modes 1 and 2 knowledge in the education of a disadvantaged student in a foundation programme such as that which has been operating under the umbrella of the CSA, has had obvious implications for the curriculum; the former to provide a disciplinary base that is inadequate in these learners, the latter to educate holistically to enable mobility in further study and beyond (see also Jacobs & Jacobs, 2002). As such, within the context of the Foundation Programme, teaching staff have needed to act as experts while simultaneously facilitating a constructivist learning environment.

Curriculum development in the Foundation Programme has thus taken place along a continuum between the traditional and hermeneutic paradigms of curriculum reform, tending more towards the latter given the constructivist philosophy of the Programme. As will become clear, this has resonance with the position this research takes along the continua across research paradigms described in the next chapter.

Within a hermeneutic paradigm the curriculum is seen as practice and is based on the teachers' professional judgment and learners' understanding. This paradigm is based on the work of Schwab (1969) who called it the "practical paradigm" for curriculum development (cited by Luckett, 1995). Within this paradigm, curriculum objectives have to be selected within the context of a particular teaching and learning process where the learners, the teachers, the subject matter and the learning milieu are all taken into account. Having as sound an understanding of this milieu as possible will clearly benefit curriculum reform, and it is here that the demography, history and current learning environment (including socio-economic and non-academic factors) of the student population will come into play. It is significant that within the hermeneutic paradigm, curriculum change is a function of wider contextual change. Curriculum change should therefore be supported by appropriate structures and institutional changes.

According to Grundy (1987, Chapter 1), the hermeneutic framework is grounded in Habermas's "practical" interests, the basis for which is understanding through interaction with a particular environment. As Luckett (1995) explains "it is the learner's understanding, thinking and reflective processes that are the central focus of the curriculum. This does not mean that learning outcomes should not be stated and aimed for, but rather that the learning processes to achieve them are more important" (p.133).

For curriculum development to take place within such a framework, reflection, reflexivity and responsible judgment are required on the part of the teaching staff. Indeed, the progressive development of the Foundation Programme curriculum has been a reflexive process in which feedback from all the participants, including students, teachers and researchers, have provided information on how each are interpreting a series of tasks (central to the curriculum philosophy) which have then been adapted in an attempt to improve the extent to which learning is promoted and achieved. This has implied learning on the part of the staff too whose responsibility it has been to find new, progressive, creative and innovative ways of teaching and facilitating learning. Working within this paradigm, staff members have expected to take responsibility for the on going development of the curricula in the modules in which they teach, and to interact with other members of staff in the development of a cohesive Foundation Programme.

What implications the devolvement of the composite Foundation modules to Schools has for the Foundation Programme in the future, is uncertain. This, however, is not the focus of the current study. Rather, it is to suggest, based on the findings of this research and the opinion of the researcher, what might be considered a good way forward for the Science Access Programmes at UKZN.

A Summary of the Research Objectives

This is a retrospective study that will record research conducted in the CSA from 2008. The objective that initiated this research at this time was the desire to provide an updated measurement of the success of the Foundation Programme, specifically the

Foundation Biology module, in meeting its goals of access and redress, and within the context described in detail above.

By the time the mainstream performance of the 2006 and 2007 Foundation student cohorts (in 2007 and 2008 respectively) had been examined, data pertaining to how the 2008 cohort of Foundation students had performed relative to the first intake of NSC matriculants into mainstream, was available. True to grounded theory methodology (see Chapter 3), circumstances at the time dictated the direction the study took; it had become evident that insight into the influence of the National Senior Certificate relative to the Senior Certificate in terms of the preparedness of students for tertiary education could feed significantly into issues of Science Access.

Findings from these initial investigations suggested that the Foundation Programme on the Pietermaritzburg campus of UKZN had indeed been successful in preparing those students who had passed their foundation year for the challenges of an important first-year, mainstream module. There were however, areas of concern which suggested it would be constructive to gain insight into what factors affected the academic performance of these Foundation Programme students (in mainstream) relative to their mainstream counterparts. In doing this, the challenges facing these Foundation students in mainstream might be better understood. In addition, this insight was seen to have potential in providing opportunities for curriculum development, both at foundation level (so as to better prepare foundation students for mainstream), and also at mainstream level so as to facilitate continuous support.

These investigations had led to a literature review of other Science Access initiatives in South Africa and had necessitated a study into existing international literature around the multitude of influences that have been found to impact on tertiary student performance. In particular, the influence of student motivation on performance attracted interest as a possible alternative to the selection criteria used by the CSA and Faculty to assess students for their potential to succeed in the Foundation Programme. Specifically, at the time, the large majority of prospective Foundation students were being turned away because they did not meet the formal criteria for selection.

As a natural progression from this point, research into the variables affecting student performance in their foundation year followed. This was seen to have potential to extend opportunities for remediation in the existing curricula which could, not only contribute to maximising a student's potential in their Access year, and their preparedness for successive Biology modules, but also possibly increase the numbers of students succeeding in the Programme. Furthermore, it was an opportunity to examine the Programmes' selection processes. Certainly within the local context and the national imperative calling for extended access to tertiary education (as described above), there was, and continues to be, merit in this investigation, and to formalise this research in the synthesised format presented here.

The following specific objectives were thus set. They represented a framework for developing a grounded theory which may inform practices in the Science Access programmes of UKZN, and perhaps beyond.

Objective 1. To provide a review of the Foundation Programme of the CSA at UKZN, and specifically the Foundation Biology module. It is against this backdrop that grounded theory-informed curriculum development in the Foundation Biology Modules can be proposed.

Objective 2. To gauge the performance of the Foundation Programme students relative to those that are augmenting first year, and those that have gained direct entry. As such, questions about the efficiency of both alternative Access routes into the Science Faculty of UKZN can be better answered.

Objective 3. To gain an insight into the factors affecting performance of the Foundation Programme students so that challenges in the Foundation Programme may be better understood and curriculum development may be informed. Here, two specific questions are asked:

Question 1: Relative to those that are augmenting first year and those that have gained direct entry, what factors are affecting Foundation student performance in their first year?

Question2: What factors are most important in determining the performance of Foundation students in their access year?

CHAPTER 2

Research Philosophy

Ontological and Epistemological Underpinnings: Implications for Methodology[6]

Fundamental to understanding research philosophy is the recognition that there exists a range of paradigmatic, ontological and epistemological interpretations. Furthermore, there is paradigmatic "interbreeding" (Guba & Lincoln, 2005), with confluences breaking down boundaries and interpretations being made along continua. Yet other authors such as Rowbottom and Aiston (2006) claim that it is highly artificial and unproductive to form an allegiance with one particular paradigmatic position since, according to these authors, they should not exist. Such a position would be an extreme one to take for this study into Foundation Life Science student performance, given that social science research on the whole is overwhelmingly dominated by authors taking one philosophical position or another. Taking a radical position is also not an attractive option when considering the alternative: the pluralistic views of educational philosophers such as Alexander (2006) as well as others who wish to take a more pragmatic stance (e.g. Johnson 2009). In addition, it would appear that there are a good many arguments against the extremes and sound argument for a more anti-dualistic position which is deemed to be more progressive in finding a position from which to take social action (see also Scollon, 2003).

This study is located within postpositivism. This position is found not only to be a very attractive practical solution to the difficulties inherent in binary conflict, but appropriate for myself as a researcher, a science graduate who has long been uncomfortable with the intransigence of (what is typically understood to be) positivism, and equally unconvinced by a radical constructionist approach. Not least, it is a convincing compromise as an educational research framework in the context of a science faculty where the discourse is typically not relativist, and quantitative methods are hegemonic.

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Postpositivism

According to Guba and Lincoln (2005), those who work within a postpositivist framework have a critical realist ontology. Yeung (1997) eloquently summarises critical realism as a philosophy that “celebrates the existence of reality independent of human consciousness, ascribes causal powers to human reasons and social structures, rejects relativism in social and scientific discourses, and reorientates the social sciences towards its emancipatory goals” (p. 52).

Some, such as Johnson (2009), Letourneau and Allen (1999) and Nieuwenhuis (2007a) concur explicitly with Guba and Lincoln (2005), while the critical realist position is more implied in the work of others (e.g. Phillips, 2004, 2005, 2006; Yeung, 1997). However, there is no consensus on this (see for example Yu, 2001). In addition, it appears that the term “realism” is interchangeably used for “critical realism” by some researchers (e.g. Healy & Perry, 2000) and understood by others to be a paradigm in itself (e.g. Krauss, 2005, Healy & Perry, 2000). To confound matters further, elements of, what appears to be, critical realism are termed post-structural (and thus essentially post-modern) by others (see for example, Trifonas, 2009). Furthermore, the ontological position of Bhaskar (1986), upon whose theory of scientific realism, critical realism is based, indicated a clear move away from anthropocentrism which has implications for epistomology.

In the face of a plethora of conflicting opinions as to the relationship between critical realism and postpositivism, I am forced to consider my own interpretation of each in the extant literature. This research thus has adopted a critical realist ontic position within the framework of a postpositivist paradigm as Guba and Lincoln (2005) would have, and an understanding of critical realism in line with Yeung (1997) (see “Critical Realist Ontology in Postpositivism” later in this chapter).

Guba and Lincoln (2005) position postpositivism along the paradigmatic continuum between positivism and critical theory, the ontology of the latter being historical realism, shaped by (socio-cultural, - political, -economic etc.) values over time, as opposed to that of the positivists (specifically those termed logical positivists) who are generally understood to be proponents of a single, apprehendible reality (although this ontological position requires some critique). It also offers, I believe, an opportunity to explore anti-dualistic approaches to research.

The original positivist is generally understood to have been Auguste Comte (Lenzer, 1975/1998); not only was he an empiricist in the foundationalist sense (all knowledge must have a “secure foundation”), but he argued strongly for the “positive method” (also known as the “hypothetico-deductive method”) as being the only way at arriving at knowledge. All forms of positivism (and there are a number including logical positivism and behaviourism, and variations of the two, see Phillips and Burbules, 2000) have this as their origin.

As the prefix suggests, postpositivism arose from these foundationalist positions to replace them. Indeed, it has been, for some time now, the understanding amongst most philosophers that (logical) positivism is no longer (see Phillips, 1983). Subsequently, Phillips (2004) has said that it would be difficult (if not impossible) to find a “knowledgeable living person who admits to being a positivist in anything like the classic sense” (p.67). Others (e.g. Johnson, 2009) agree, although there appears to be a great deal of concern that the revised philosophical understandings have not infiltrated educational and social science research as much as would be desirable.

Positivism is seen by some researchers (e.g. Howe, 2009) to be tacitly pervasive in the social sciences and indeed many claim that it persists as an integral part of wider societal systems (Phillips, 1983/2004), and in everyday discourse (e.g. Scollon, 2003). Undoubtedly there has been a continued tendency for the term “positivist” to be used abusively and indiscriminately (Johnson, 2009; Matthews, 2004; Phillips, 2004). This, claims Phillips (2004) and his colleague, Burbules (Phillips & Burbules, 2000) is a consequence of misconceptions around positivism itself which need to be acknowledged before consideration may be given to those aspects of positivism that have been discarded to reveal postpositivism in its contemporary form. Indeed, when referring to critical texts such as Matthews (2004) it is hard to explain how the popular understandings of “positivism” have come to exist; nonetheless it is certainly more common to find contemporary interpretations of positivism that do not agree with “positivism” as described by this author. It is to this popular understanding of positivism I refer when examining postpositivism as the emergent paradigm: a positivist is commonly understood to believe to have access, through their research methods to a fixed, unchanging and absolute reality.

As Phillips and others (e.g. Johnson, 2009; Matthews, 2004; Rowbottom & Aiston, 2006) point out, many opponents of positivism are not clear what actually characterises this position, not least of which is that positivism does not necessarily adopt a realist ontology. Realism per se is not problematic, and indeed scientific and critical realism are growing movements amongst postpositivists (Johnson, 2009; Yu, 2001). However, realism within the classical positivist sense, where there is rejection of metaphysics, amounts to the static naïve reality of a world that is restricted to that which can be empirically verified. For the logical positivists, it was meaningless to make statements about phenomena that could not be verified in terms of possible sense experience. This position assumes that empirical methods lead to "truth" and it is possible to identify laws governing human behaviour that would hold true in all cases. This view is expounded by the most well meaning educational research authors (see Cohen, Manion & Morrison, 2000). This has contributed to false dichotomies mentioned above ("dubious bifurcations", Rowbottom & Aiston, 2006, p.137) between positivist and interpretivist/constructivist research; between realist and nominalist ontologies (and misunderstandings of these actual terms).

Positivism and the Fallacy of Realist Ontology

Actually these positions are not as clearly distinct. Rowbottom and Aiston (2006) demonstrate that a positivist approach does not necessarily assume a realist position (as indeed an anti-positivist need not assume a nominalist one). These authors, by critiquing the term "nominalism" point out that this position need not deny the existence of "any concrete particular …or their non-verbal, non-conceptual access to it" (p.142). They do deny however the existence of universals or abstract concepts as they are merely names without a corresponding reality. Given this explanation, these authors point out that nominalists can be realists. Indeed, as Bhaskar (1986) declares: "In its broadest sense in philosophy any position can be nominated 'realist' which asserts the existence of some disputed kind of entity" (p. 5).

On the other hand, other authors explain that, contrary to popular belief, the (classical) positivists were anti-realists - certainly with respect to theoretical entities. Their rejection of metaphysics (and therefore the idea of a metaphysical ultimate reality) saw to this. Johnson (2009), Phillips and Burbules (2000) and Matthews (2004) (see also Phillips, 2004) refute Guba and Lincoln's (2005) classification of positivism as having a realist ontology, describing the classical positivists as being instrumentalists or as following phenomenalism or sensationalism (see also Phillips & Burbules, 2000 and Yu, 2001). Certainly the logical positivists saw theoretical entities as conceptual tools (instruments) that could assist in predicting facts (these being sense experiences); according to a logical positivist, only the reality of the *experienced* world should be accepted (accepting that the world as it really is could (can) not be studied).

Indeed, it is interesting to identify this instrumentalism in the original work of Cronbach (1957) who is perhaps most well known for his validation of constructs and associated measures of scale reliability (Field, 2009). Cronbach acknowledged the influence of logical positivism on his work and was persuaded more towards the correlational discipline in the field of what he called “scientific psychology” than towards an experimental approach (Cronbach, p.67). Phillips (2004) highlights that Cronbach recognised that to be consistent with logical positivism, it was essential to have an instrumentalist; and not realist, view of the nature of constructs.

In addition, contemporary postpositivists are clear that a commitment to claims of absolute truth need not be made in the pursuit of knowledge. Dewey’s “warranted assertions” are deemed more appropriate (Phillips & Burbules, 2000, p. 3). As these authors explain, whilst people have multiple beliefs and these are often accepted as “truths”, it is essential to acknowledge that beliefs may not necessarily be true. In addition some things are not “true or false”, they simply “are” (p. 37) and thus the truthfulness (or otherwise) refers to the *propositions* (statements) *about* these things (and whether reasonable warrants have been made for their assertion). Furthermore, rather than describing *total* reality (all truth), it is more pertinent to be seeking *relevant* truths (apropos the last comment, relevant true statements). In other words, what research should be seeking, are warranted “beliefs” or assertions that are sufficiently strongly supported so that confident, progressive action may be taken upon the basis thereof. Clearly then, it is not realism that postpositivism has rejected since not only does it appear that there are anomalous understandings of the ontology of positivism, but that critical realism is a distinct possibility in postpositivism.

To further explain the misunderstandings around positivism, Phillips (2004) reports that the term positivism is sometimes used as a label for empiricism. Indeed, logical positivism was a form of empiricism, but certainly not all empirical methodologies are positivist; pragmatists (e.g. Johnson & Onwuegbuzie, 2004) endorse a strong and practical empiricism as the "path to determine what works" (p.18). Phillips (2005) suggests that empirical education research has not, in the main, been well treated by philosophers, and there is a mismatch between philosophy and those conducting empirical education research. Whilst this author (Philips & Burbules, 2000, p. 16), quoting Hanson (1958), acknowledges that there is certainly "more to seeing than meets the eyeball", and that more than empirical evidence informs conceptual decisions (Phillips, 2005), he considers the wholesale rejection of empiricism by the more radical of the social constructivists "extreme" and "bizarre" (Phillips, 2004, p. 77) (see also Matthews, 2004). Surely, one would have to agree.

Quantitative methods are not Necessarily Positivist; Qualitative Methods are not Necessarily Constructivist

All too often quantitative research is seen to be the sole domain of the logical positivist (Yu, 2001). Others, for example, Scollon (2003), make this assumption in the context of "popular positivism" (alluded to earlier). This author goes on to illustrate that he too, makes the commonly held assumption that positivists, by default, are realists (who operate within a quantitative discourse): "…thus postmodernist inter-discursivity runs side by side, often in the same person, with the positivist, realist notion that somehow there is a solid, non-discursive world about which we can speak the truth without doubt" (p.72).

Nieuwenhuis (2007a) (whilst going to some length himself, to draw distinctions between positivist (and therefore quantitative) and qualitative research) cites Seale (1999) as claiming that postpositivism is an appropriate paradigm for those researchers who wish to draw from some of the "aspects of positivism such as quantification" (p.65), yet are inclined towards the more subjective interpretivist views and wish to incorporate both quantitative and qualitative research methods. Whilst well meaning, (and in the latter part, correct) such recommendations serve to contribute to the widespread understanding that quantitative methods are positivist. It is also worth noting that it tends to be the qualitative purists who portray this view of quantitative methods (see for example Guba and Lincoln, 2005). This polarisation of quantitative from qualitative methods has led to incommensurable epistomologies that have contributed to the paradigmatic dichotomy alluded to above. Howe (2009) describes the "qualitative-quantitative incompatibility thesis" saying that such methods can only be combined with separately assigned roles. On the other hand it has long been recognised by some that quantitative and qualitative methods serve different purposes and that "the problem under investigation (should) dictate the method of investigation" (Trow (1957) cited by Sieber, 1973). It is fair to say that postpositivism does heartily engage in the use of quantitative methods (going as far as to traditionally write (with some authority) in the third person usually associated with the neutral rhetoric associated with the natural sciences) (Denzin & Lincoln, 2005; Johnson & Onwuegbuzie, 2004; Ryan, 2006), but there is no reason why they should be exclusively associated with this paradigm (Jick, 1979; Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie & Turner, 2007; Phillips & Burbules, 2000; Yu, 2001).

In fact, postpositivism relies on multiple ways of capturing as much of reality as is possible, and exhibits the use of both qualitative methods (that may be analysed in a structured manner, perhaps relying on statistics) and quantitative methods that depend on (low-level) statistical analyses (Denzin & Lincoln, 2005, Healy & Perry, 2000; Phillips & Burbules, 2000, p. 86). This mixed methods research approach is advocated by Johnson and Onwuegbuzie (2004) as a pragmatic solution to the traditional qualitative- quantitative divide (see also Alexander, 2006). Whilst not making explicit the relationship with critical realism, the philosophy of Johnson and Onwuegbuzie (2004) is apparently the same, reminiscent of Popper's world three which opposes dualisms. Mixed methods research, according to Johnson and Onwuegbuzie's (2004) definition is "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p. 17); that is not only the nature of the data and how it is analysed.

Yeung (1997) is clear on the central role of qualitative methods in critical realist research and asserts that quantitative methods can help establish empirical regularities between objects, and as such inform the abstraction of causal mechanisms. Guba and Lincoln (1994) neatly summarise this too, whilst drawing a distinction between positivism and postpositivism in the use and interpretation of quantitative methods. The former, these authors claim, seek to verify hypotheses through experimentation, whilst the latter seek to falsify them through means in addition to the typically reductionist experiment. This is an important distinction. The 'falsifiability criterion' introduced by Karl Popper lies at the very heart of modern inferential statistics (Magnusson & Mourao, 2004; Quinn & Keough, 2002; Winch & Gingell, 1999). By arguing that "certainty or even high probability in knowledge is an illusion" (because universal claims can seldom be proved on the basis of particular experiences), Popper contested the logical positivist claims about truth and knowledge (Murray, 2001; Nieuwenhuis 2007a; Phillips, 2004). This is appropriate, given an understanding of Popper's notion of three worlds. Popper's "world three" is related to (critical) realism and consists of "abstract things that are born of people's minds but exist independently of a one person" (Healy & Perry, 2000, p.120). Thus within a postpositivist research tradition, "all knowledge is fallible, but not equally fallible" (Yeung, 1997, p. 54); only probabilistic claims can be made. With this understanding the bulk of contemporary research in the natural sciences can also be called postpositivist (see also Ryan, 2006).

The epistemology of modified objectivism is reflected by these methodologies – that rigorous research will generate findings that are "probably true" (Guba & Lincoln, 2005, p. 195). Popper saw this as the regulative ideal (Phillips & Burbules, 2000). Fallibility should not be seen as a failing, claim these authors; "the fact that we are fallible is no criticism of the validity of the ideal because even failing to find an answer, or finding that an answer we have accepted in the past is mistaken, is itself an advance in knowledge" (p.3). In the words of those who advocate a pragmatic approach to research: "Capital 'T' truth is what will be the final opinion, perhaps at the end of history. Lowercase 't' truth (those instrumental and provisional truths that we obtain and live by in the meantime) are given through experience and experimenting … these are a matter of degree … not stagnant, and we must be ready tomorrow to call them falsehoods" (Johnson & Onwuegbuzie, 2004, p. 18).

The Impossibility of Complete Objectivity and Value-Free Observation

Guba and Lincoln (2005) expand on the "modified objectivist" epistemological underpinnings of postpositivism. Here, researchers are aware that objectivity is an ideal that can never be achieved, and as such, research is conducted with a heightened awareness of subjectivity with an understanding that, in part, "reality" is a creation of the individuals involved in the research (see also Phillips & Burbules, 2000, distinction between subjectivity and bias, and acknowledging objectivity whilst having a particular frame of reference). This does shed some doubt on the possibility of the positivist notion of "disinterested scientists" as the informers of decision makers, policy makers and change agents (Guba & Lincoln, 1994, p. 196). Postpositivism heartily acknowledges the relativity of the "light of reason" (that what appears reasonable to one person may not to someone else) (Phillips & Burbules, 2000). It also recognises that perception is theory laden in so far as a researcher's background knowledge and experiences will affect his or her decisions around what to study, or what elements of the data to emphasise or publish. Even the selection of a statistical alpha level is open to subjective choice (and manipulation) (Field, 2009; Lösch, 2006).

Associated with the notions of subjectivity and objectivity are values. Howe (2009) describes the fact-value divide associated with positivist and anti-positivist research, this to an extent attributable to the (false) dichotomy between quantitative and qualitative methods mentioned above and also to the (false) notion that quantitative methods are positivist. Whilst not value-intense as are more constructivist approaches, postpositivism is conscious of the values of human systems and of researchers (Krauss, 2005; Ryan, 2006). Ryan (2006) cites Eagleton (2003) when describing the kind of objectivity she sees as required of a postpositivist approach: "... an ability to see the whole picture, to take a distanced view or an overview. But this kind of objectivity is different from 'just the facts', devoid of context – it does not mean judging from nowhere it requires a fair degree of passion – especially passion for justice and the ability to subject one's own assumptions to scrutiny" (p.18).

Whilst Johnson and Onwuegbuzie (2004) point out "… fortunately (most) qualitative researchers and quantitative researchers have reached basic agreement … researchers are embedded in communities and they clearly have and are affected by their attitudes, values and beliefs … human beings can never be completely value free, and that values affect what we choose to investigate, what we see, and how we interpret what we see" (p. 16), Phillips & Burbules (2000) illustrate the modified objectivist stance by drawing attention to the difference between epistemically irrelevant, external value influences (dangerous bias) and internal, relevant values in scientific work.

This has implications for the researcher and the researched, placing postpositivism along an epistemological continuum between positivism and constructivism where the former views the "object of study" as independent of the researcher, and the latter requires the researcher to interact with the "subjects (participants) of study" and co-construct knowledge (Krauss, 2005). Indeed, Denzin and Lincoln (2005) assert that one fundamental way that researchers who do not work within the positivist or postpositivist traditions differ from those who do, is that the former feel these more "distanced" approaches silence “too many voices” (p. 12). With the engagement of mixed methods, this need not be so, although it is acknowledged that this will be a limitation of research that employs solely quantitative methods of data collection and analysis.

Misunderstandings around “Science” and Rigour

Furthermore, it is clear that there are many who confuse rigorous research with positivist research. Phillips (2004, 2005) condemns the use of the term ‘positivist’ to describe any researcher who “simply advocates clarity in language, competency in research data collection and analysis, or care in argumentation … or who happens to advocate a research technique (such a randomised controlled experimentation)” (2004, p.68) or statistics (2004, p.78). Guba and Lincoln (2005) appear to take this view, drawing a comparison between the positivist’s and postpositivist’s conventional quality standards of rigour, internal and external validity, reliability and objectivity, and less rigorous criteria of non-positivist research (see p. 196). In many instances of postpositivist research, these notions of quality have been modified (see later Chapter 3, Grounded Theory).

Another misconception that is apparent, concerns the question of what “science” (as in the natural or exact sciences) actually is (Johnson & Onwuegbuzie, 2004; Phillips, 2005; 2006; Rowbottom & Aiston, 2006). This too has resulted in a (false) dichotomy: that of the empirical sciences-humanities (see Howe, 2009). Whilst it is clear that modern science has progressed far beyond the narrow, restrictive, unattainable ideals laid down by the original Comtean-type and logical positivists, it is also evident that there is a pervasive notion that “science” is still narrowly defined to “the scientific method”. Indeed, as Scollon (2003) points out, there is “vagueness” amongst practitioners (in all fields of enquiry) about the epistemological and ontological status of the basis for the hypothetico-deductive approach to science. This is problematic for the postpositivists in that, through their association with quantitative methods and their positivist connotations, their way of doing science is often seen to be confined to the hypothetico-deductive approach of “the scientific method” of the natural sciences. And this is often equated with “the gold standard” experimental method, a perception that has been reinforced, not least in the form of funding (for example in the USA) (Phillips, 2005). This seems extreme, given that even Comte acknowledged different forms of his original “positive method” that did not exclude non-experimental forms of verification (see Lenzer, 1975/1998, p. 99). In addition, Popper, widely acknowledged to having resolved some of the solutions to the problems of verificationism, professes there to be no such thing as *the* “scientific method”, only problems and “the urge to solve them” (Rowbottom & Aiston, 2006).

“The Problem of Induction”; Unproblematic Inductive Research

A clear distinction can however be made between positivism and postpositivism in the purpose of the research. Whilst the latter is traditionally seen to be able to establish laws based on absolute truth, and generalise accordingly (Sieber, 1973; Nagel, 1986 cited by Johnson & Onwuegbuzie, 2004), the postpositivist focuses on describing phenomena in valid and reliable terms (Denzin & Lincoln, 2005; Nieuwenhuis, 2007a). Postpositivism is quite clear on the problem of inductive generalisation; we have no way of being certain that the future will resemble the experienced present or past (Phillips & Burbules, 2000). While postpositivists on the whole, are not clear on how to resolve this problem (see also Bassey, 2001 and Hammersley, 2001), one particular critical realist perspective (Yeung, 1997) holds that generalisations made are “universal” only at “specific temporal-spatial intersections” (p.57). This is seen to represent an alignment with the substantive grounded theory discussed later.

Associated with these issues around uncertainty are the postpositivist understandings concerning the underdetermination of theory by evidence (that there are many competing theories that observational evidence may support) and the problems concerning auxiliary assumptions (the so-called Duhem-Quine thesis) (Phillips & Burbules, 2000). Postpositivist authors (e.g. Phillips, 2004; Phillips and Burbules, 2000; Johnson and Onwuegbuzie, 2004) are quite clear on the move away from positivism with regards to these issues.

In line with the extent to which generalisation is possible (or appropriate), there is a dichotomy between positivism and postpositivism in the respective deductive and inductive research strategies employed. As Fick (2002) cited by Denzin and Lincoln (2005) explains, this is a consequence of rapid social change and the resulting diversification of contexts and perspectives. No longer is it appropriate or possible to make use of deductive reasoning to test theories within an ever-changing world, but rather we need to employ inductive strategies that concentrate on local knowledge and practice. Yeung (1997) concurs by explaining that (critical) realist research is *a posteriori* – that given “the social reproduction of knowledge, a critical realist seeks to reconstruct causal structures and their properties on the basis of constant reflections and immanent critique" (p. 57). As such, history and context are highly relevant in the realisation of causal mechanisms. This is seen here to be a key distinction between postpositivist research and positivist. According to Bhaskar (1986) it is not possible to conduct research in the social sciences within the positivist paradigm, as to isolate a single process or mechanism from the "interfering flux of the open world" is not feasible. Postpositivist research presents the opportunity to accompany explanations of the social world with direct experience and practice. Grounded theory methodology appears to offer much in this respect.

After Positivism - Postpositivism

It is thus possible to clarify what aspects (supposed aspects if one were to consider the views held in Matthews, 2004) of positivism have been relegated to history, rendering postpositivist research in its current form. It is the very narrow, fundamentalist empiricist view of the nature of science held by the Comtean and logical positivists and behaviourists (as in their determined focus on the "observed", strict reasoning about those observed phenomena, and their rejection of the "inferred") (see Phillips & Burbules, 2000, p.13). It is a rejection of the naïve empiricist observations, manipulations or physical operations as the only methods of justification. It is the rejection of the notion that Comte's positive method ("the scientific method") is the only way of arriving at knowledge. Certainly, it is a rejection of the logical positivist's hostility toward metaphysics. It is the rejection of positivist negligence on the part of the purposive actions of humans. It is also, at the other end of the spectrum, a rejection of postmodern hermeneutics (Yeung, 1997).

It is not their inclination towards quantitative methods such as experimentation, statistics and empirical data.

The opening up of postpositivism to embrace a critical realist philosophy in line with that described by Yeung (1997) earlier is seen to be one of the hallmarks of the paradigm. Here "critical" indeed refers to both the ontic concerns (see below) and to the emancipatory, social-transformative goals of critical theory espoused by the likes of Foucault. Indeed, Bhaskar (1986) holds that "the possibility of an (explanatory) critique constitutes the kernel of the emancipatory potential of the human sciences…" (p. 180). Contemporary advisors concur. Ryan (2006) claims that postpositivist research principles not only emphasise meaning and the creation of new knowledge, but are able to support committed social movements "that aspire to change the world and contribute towards social justice" (p.12). Scollon (2003) agrees by alluding to his uneasiness around the stated emancipatory goals of, at the other end of the philosophical continuum, some (radical) constructivist approaches.

Critical Realist Ontology in Postpositivism

There are many adaptations of critical realism, but it is typically understood to be the social sciences version of scientific realism based on the work of Roy Bhaskar (Collier, 1994; Scollon, 2003). Scientific realism, according to Bhaskar (1986) asserts the "existence and activity of the objects of scientific enquiry absolutely or relatively independently of the enquiry of which they are the objects or more generally of all human activity" (p. 5). That is, the existence of phenomena independent of scientists and human activity and theorising. Realism, as Bhaskar would have, assumes a metaphysical reality and is a move away from anthropocentrism. It is a theory of *being* (rather than primarily truth or knowledge); consequently, the objects investigated by the sciences operate independently of the human activity in pursuit of knowledge (of them). Hence they exist independently of the sense-experience and thought of the human investigation. This *transcendental realism* does not assume either empiricism or rationalisation "wherein being is defined in terms of the human attributes of experience and reason" (p. 6).

Bhaskar's *critical naturalism* seeks to apply the transcendental model of science to the human world to identify the mechanisms producing social events whilst acknowledging that these are in a greater state of flux than is so in the physical world. In addition it must be acknowledged that intention and conscious reflection are characteristic of human agency (Yeung, 1997). Although Bhaskar himself does not refer to the term "critical realism", this term, a blend of "scientific realism" and "critical naturalism", is generally used by social researchers when aligning themselves to Bhaskar's philosophy.

Critical realism is a rejection of "positivism" as defined by Bhaskar: "… the "omni-competence and unity of science" (Bhaskar, 1987, p. 226). He goes on to say that "in its most radical shape it (positivism) stipulates that the only kind of (non-analytic) knowledge is scientific, that such knowledge consists in the description of the invariant patterns, the co-existence in space and succession over time, of observable phenomena; and that the role of philosophy is analysis".

Underpinning critical realist research philosophy is the recognition that there is a "real" reality but this is, and can only be, imperfectly understood; it can only be approximated (Guba, 1990 cited by Denzin & Lincoln, 2005). Critical realists, in the tradition of Bhaskar's external realism agree with the positivist notion that there is a world independent of the human consciousness that needs to be studied; but assert that knowledge of that world is socially constructed (Dobson, 2002). This author explains that, for a critical realist, "reality" and the "representations of reality" operate in different domains; a divide exists between the intransitive ontological dimension and a transitive epistemological one. This is in line with Poppers' "three ontological worlds" as alluded to above. Murray (2001) cites Popper as having said "… my conviction that there is a real world, and that the problem of knowledge is the problem of how to discover this world" (p. 266). Indeed, Popper, unlike the logical positivists, and in reaction to them, regarded metaphysics as having importance and meaning whilst simultaneously having an enduring concern about the empirical basis of science (Murray, 2001). He was very clear that observing was not a theory-free activity (Phillips, 2004). In addition, Popper believed that "absolute truth would never be attained by human beings" (Phillips & Burbules, 2000, p.3).

Yeung (1997) and Dobson (2002) explain Bhaskar's understanding of the so-called epistemic fallacy: that statements about being (ontological statements) can be analysed in terms of statements about knowledge of that being (epistemological statements). At the very core of critical realism is the assertion that "real objects are subject to value laden observation"; the *reality* and the value-laden *observation of reality* operating in two different dimensions, one intransitive and relatively enduring; the other transitive and changing" (Dobson, 2002, see also Bhaskar, 1986). Indeed, Bhaskar himself is quoted by Dobson (2002) as having said: "... there is no conflict between seeing our scientific views as being about objectively given real worlds, and understanding our beliefs about them as subject to all kinds of historical and other determinations" (no page number).

Healy and Perry (2000) provide a useful summarising explanation (albeit, in my opinion, incorrectly referring to (critical) realism as a paradigm itself): (critical) realism concerns "multiple perceptions about a single (mind-independent) reality" (p. 123). Scollon (2003) provides us with an even simpler description of critical realism: a realist's ontic view, coupled with a constructivist epistemic position (p.78). This resonates with the view of Alexander (2006) that “knowledge – at least in education – is always the possession of an embodied agent, constrained by language, culture and history, who grasps, albeit imperfectly, the contours of an entity or the meaning of an idea that transcends – exists independently or outside of – his or her limited experience. And this requires … the existence of ideals beyond our own contextualised experience whose ultimate content remains shrouded in culture, history, language and tradition” (p. 214). This author says much on the importance of acknowledging fallibility and cautioning against predictions that may be made too readily. For me, this embodies critical realism, and a breaking down of divisive constructivist and realist ontologies.

For the Bhaskarian (critical) realist, the intransitive dimension will always be the most important consideration for methodological approach, the aim being to unearth the real mechanisms and structures underlying perceived events (Dobson, 2002).

Having said this, a critical realist conducting postpositivist research must extend their methodologies beyond quantitative measurement, *description* and *prediction* to include an *understanding* of the mechanisms, processes and structures that account for the patterns observed (Denzin & Lincoln, 2005). Thus whilst the ontological basis for postpositivism distinguishes it from the relativist tenets of constructivism, there is some sharing of methodologies. It is to this matter of methodology that Chapter 3 turns.

CHAPTER 3

Research Methodology

Methodological Considerations for Critical Realist Research

Yeung (1997) believes that critical realist research has been methodologically underdeveloped, with practical methods not being sufficiently explored and interrogated within the conceptual framework. As this author asserts, critical realists believe in "abstraction as a useful tool to reclaim reality" (p. 56). By what methods this "abstraction" may be achieved, whilst remaining faithful to the philosophical underpinnings (the methodology), is the challenge.

Naturalism is deemed to be a possible methodological approach for a researcher working within a critical realist framework (Yeung, 1997). A naturalist methodological position is more often viewed as typical of constructivist paradigms that assume subjective epistemological and relativist ontological positions (Denzin & Lincoln, 2005). These findings are often presented in terms of grounded theory (Guba & Lincoln, 2005) with explanations being generated inductively (Johnson & Onwuegbuzie, 2004). Yeung (1997) on the other hand, suggests grounded theory has methodological potential in critical realist research. Grounded theory is widely recognised to be theory building rather than theory testing, and indeed, was developed as an alternative approach within the positivist tradition (Nieuwenhuis, 2007b). Two other methods for pursuing critical realist research suggested by Yeung (1997) are "iterative abstraction" (p. 58) and triangulation (p. 64). As will become apparent, iterative abstraction and triangulation are deemed to be inherent in grounded theory methodology.

It must be noted that for the purposes of this introduction, a distinction between "methodology" and "method" has been made in line with Grix (2002). That is, one's "methodology" (underpinned by ontological and epistemological assumptions) considers what research procedures or logic should be followed, and "method" specifies techniques used to produce and analyse data. As such, the emphasis here in this introductory chapter is on methodological deliberations. It should also be noted that for the research documented in this dissertation, a case study approach might have been adopted which perhaps would have been more conventional (and less risky). According to Fei (2009) though, grounded theory and case study research differ in significant ways that make them incompatible methodologies. Whilst case studies place emphasis on describing particular, fairly isolated social units and do not exhibit the abstract conceptualisation of grounded theory, it is the latter that this current study has sought to achieve.

Furthermore the postpositivistic approach to grounded theory, with its notions of rigour and ideals of objectivity, fits comfortably in the field of the natural sciences, the area in which I have spent the past ten years teaching. Similarly, Kennedy and Lingard (2006) acknowledge that the postpositivistic location of the initial conceptions of grounded theory (see Annells, 1997; Charmaz, 2005; Glaser & Strauss, 1967/1999) allows this methodology significant relevance in the domain of medical education. Furthermore, grounded theory research is viewed by these authors as being highly suitable as the basis toward developing and implementing practical educational innovations.

As already outlined in Chapter 1, it is hoped that the research presented here may be able to offer insight into areas of the undergraduate life science curriculum at the University of KwaZulu-Natal (UKZN) that may need remediation and in doing so, serve as a starting point for implementable educational innovation. The Centre for Science Access and my teaching position therein, thus represents the departure point for this Grounded Theory study, documented retrospectively as I seek to provide a synthesis of my research in the CSA over the past few years.

The employment of the quantitative methods (specifically the classification and regression tree analysis, see Chapter 6) in pursuing this grounded theory within a postpositivist framework is what I offer as innovative in attempting to qualify this study as worthy of a doctoral degree. A comprehensive search of international literature has not revealed a study similarly positioned using this methodology, complete with specific methods employed.

Grounded Theory Methodology

As has been mentioned, grounded theory (GT) is widely recognised to be theory building rather than theory testing. By this method theory is grounded in, and develops from, data that has been collected and analysed. This data often extends to everyday accounts and observations, and by the majority of contemporary accounts, grounded theory is a qualitative methodology (despite the possible use of quantitative methods). Thus, according to Niewenhuis (2007b, p. 77) the approach of “the scientific method” (and here it must be assumed that he is referring to the contemporary understanding of positivism described in the previous chapter), where theory is first developed and then tested empirically, is inverted.

Indeed, it is worth briefly considering at this point, the different understandings of the goals of “theory”. To someone closely aligned with positivism (as in the classical sense, and as understood in the general public domain), the goal of (a scientific) theory would be the provision of an explanation that is supported by a wide body of evidence, achieved through the highly organised processes of the hypothetico-deductive method (for one of many examples of this to be found in Natural Science text books see Purves, Sadava, Orians & Heller, 2001, p. 11). Cohen, Manion and Morrison (2000) cite Kerlinger (1970) in support of this understanding: a theory (in the “scientific sense” is “a set of interrelated constructs, definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables with the purpose of explaining and predicting the phenomena” (pp. 10-12). By contrast, Scollon (2003) points out that the goal of “theory”, taking a constructivist view, is that “of ferreting out the histories and socio-cultural positions of statements about the world” (p. 76). According to this author’s interpretation, a “theory” as such, ceases to exist as an entity, a statement made within the discourse of (positivist) science. Instead, it alters into the nominalised form of itself, “theorisation” which leads to a deconstruction of a given, presented world where historical and socio-cultural origins are concretised. Having outlined my understanding of the epistemological basis for these alternative standpoints, (and their emancipatory potential) in the previous chapter, it is contended here that grounded theory can be positioned between these extremes, a position that can be considered more pragmatic and progressive than either of these options, and from which social action may be taken.

Grounded theory was originally described by Glaser and Strauss in 1967 as a “general method of comparative analysis” (1967/1999, p.1). These authors asserted that, in combination with inductively directed positivist content analysis, substantive theory derived from the data may inform theory development rather than be driven by theory (Glaser & Strauss, 1967/1999; Henning, 2004). Their objectivist stance places Glaser and Strauss’s original conceptions in the realm of postpositivist research (Annells, 1997; Henning, 2004; Kennedy & Lingard, 2006; Denzin & Lincoln, 2005). In contrast, Charmaz (2005) elaborates on a more constructivist version of grounded theory. Despite their differences, these most well-recognised grounded theory methodologists agree that grounded theory is an integrated research strategy that may be seen as a "total methodology", that provides principles for the entire research process (Weed, 2009). Many versions (Niewenhuis, 2007b), opinions (Hallberg, 2006) and indeed, misinterpretations (Weed, 2009), of grounded theory currently exist based on researchers' ontological and epistemological views. For example, Henning (2004) sees grounded theory as the manner in which all good inductive inquiry should be conducted – started with multiple examples and narrowed down, data (and not theory) driven, and with higher levels of abstraction. She does not view grounded theory as a particular methodology at all. At the extreme, there are authors that posit that there is no place for grounded theory in (qualitative) inquiry (e.g. Thomas & James, 2006). Others (e.g. Fernández et al., 2007, Hallberg, 2006; Kennedy & Lingard, 2006) describe it is a rigorous, relevant methodology that suits pragmatic researchers.

Grounded Theory: An Historical Perspective

The original proponents of grounded theory, Glaser and Strauss, came from different research traditions, the former from a typically positivist background, and the latter from one that is more constructivist (Hallberg, 2006). Glaser (e.g. 2004) is clear that it is a conceptual theory generating method with the emphasis being placed on explanation and prediction rather than description. For Glaser, conceptualisation is everything: a concept is the "naming of an emergent social pattern grounded in research data" (2002a, p. 4). Kennedy and Lingard (2006) provide a succinct iteration of this by describing grounded theory as a methodology designed to develop a well-integrated set of concepts that provide a theoretical explanation of a social phenomenon. Glaser's modified objectivist view is illustrated by referring to the informants of a study as having their own perspectives when telling their stories, but the researcher (with attempted analytic distance, but acknowledged to be another perspective all the same) raises these perspectives up to an abstract level of conceptualisation in order to attempt to see the underlying pattern (Annells, 1997; Glaser & Strauss, 1967/1999; Glaser, 2002a; b). This view of the researcher's role as a "sensitized and systematic agent" (p.251) is evident in Glaser and Strauss (1967/1999); "of course the researcher does not approach reality as a tabula rasa. He must have a perspective that will help him see relevant data and abstract significant categories …"(p. 3), "… when he begins to hypothesize with the explicit purpose of generating theory, the researcher is no longer a passive receiver of impressions but is drawn naturally into actively generating …"(p.39). In later work (Glaser, 2004) this distanced role of the researcher is also clear: "… when I say that some data is interpreted, I mean the participant not only tells what is going on, but tells the researcher how to view it correctly … adding his or her interpretations would be an unwarranted intrusion of the researcher" (paragraph 8).

By comparison, Strauss, emphasised conceptual/theoretical description (Strauss & Corbin, 1998; Corbin & Strauss, 1990), and also sought more to portray the voice of the source of the data (participants or interactants). Glaser's version of grounded theory is now termed "classical grounded theory"; Strauss', "the reformulated grounded theory" which tends to be more interpretivist (Annells, 1997; Hallberg, 2006).

Hallberg (2006) acknowledges that Strauss and Glaser tended towards postpositivism to different degrees and in various ways; in many instances the latter is cited as being closer to the positivist paradigm than Strauss. Strauss had a more relativist ontological view, Glaser more objectivist. According to Glaser himself (2004), the GT researcher needs to "maintain analytic distance … and be open to conceptual emergence" (p.11). Certainly this emphasis on "emergence" of reality (as independent of the researcher) suggests that this author tends towards a more objectivist view. Indeed, some authors (e.g. Weed, 2009) view Glaser as being very close to the positivist extreme of the paradigmatic continuum. Annells (1997) argues however that Glaserian grounded theory is decidedly postpositivist. From what Glaser has said (e.g. Glaser, 2002b), it is my view that grounded theory in the tradition of Glaser can indeed be seen as postpositivist, the researcher maintaining the position of the modified objectivist, thus taking the ontological position of a critical realist (see also Annells, 1997). Yeung (1997) reinforces this position by explaining that, within the framework of (critical) realist GT, there is room for a down scaling of the subject's narrative typical of constructivist type grounded theory. This author recognises that much information on "structural context and contingency" (p. 63) is unavailable from interpretivist methods such as interviewing, and it is here, that the researcher must elevate him or herself above the data. This research thus has been conducted primarily in the tradition of Glaser.

According to Glaser (2004, p.12), grounded theory provides an honest approach to data that lets the "natural organization of substantive life emerge". It can, in general be described as theory that is "inductively derived from the study of the phenomenon it represents" (Glaser & Strauss, 1967/1999; Corbin & Strauss, 1990). It is in this development of theory that it is distinguished from other methodological approaches. As the name implies, grounded theory seeks to ground the theory in the data that is systematically collected and analysed; this aspect of the method is therefore inductive rather than deductive. Data collection, analysis and theory formation are integrally connected, with initial data analysis shaping further data collection. Thus, as understood by Hallberg (2006), the "systematic abstraction and the conceptualization of empirical data constitute the theory-generating process" (p.143). Henning (2004) supports this understanding by describing grounded theorists as those researchers who "theorise reality according to a set of empirically organised categories" (p.115).

This abstraction within the context of critical realist research however can be seen to be more deductive in nature; "indeed, deductions from grounded theory, as it develops, are the method by which the researcher directs his theoretical sampling" (Glaser & Strauss, 1967/1999, p. 32). Although causal categories can emerge from the data, relations amongst them must be abstracted in conjunction with theorisation and immanent critique, which are essentially a posteriori processes. Consequently the (critical) realist method for theory construction should engage a deductive-inductive dialectic (Glaser & Strauss, 1967/1999; Yeung, 1997). Importantly Yeung (1997) points out that the "role of the realist researcher is to achieve a harmonious synchronization between deductive abstraction and inductive grounding of generative mechanisms" (p. 63). This is fundamental to understanding GT in the context of critical realist research.

Despite their differences, Glaser and Strauss generally agree/d on what a "theory" in grounded theory research means; that "theories" are integrated concepts that contribute to the understanding of phenomena. They also concurred that "theory" in this context refers to "substantive theory" – that which is applicable to a delimited area rather than having a very broad applicability (Hallberg, 2006; Weed, 2009). Glaser (e.g. 2004) is clear though that grounded theory does have general implications and can be applied to other substantive areas through the process of constant comparative method, and theory modification described below. This resonates with the "fuzzy generalizations" described by Bassey (2001) (see later), and surely places such research, appropriately within critical realism (Weed, 2009), and as such characteristic of postpositivist research. Formal theory can be generated out of substantive theory by diverse area comparisons. This move from substantive to formal theory assumes the acknowledgement of an underlying reality across substantive areas (Weed, 2009).

Weed (2009) cites Downward (2006) to explain that when "paired with critical realist assumptions, grounded theory is a coherent methodological approach" (p. 508). Reminiscent of transitive and intransitive dimensions of reality as described by Dobson (2002), Weed (2009) refers to critical realism as having a stratified ontology across three domains: the real, the actual and the empirical. The latter explains that there are real causes to actual events which are constant over time. The empirical understandings of these real causes (made possible through observations of actual events) however are dynamic; i.e. the understanding of the meaning of observations change as methods and bodies of knowledge grow. Within the context of grounded theory, this critical realist ontology, combined with elements of interpretivist epistemology, allow for a contribution to the formal body of knowledge to be made about this underlying reality, whilst at the same time, recognising that this is open to revision (since interpretations of that reality are subject to change).

Glaserian Grounded Theory

The generation of grounded theory is systematically achieved through a set process (Glaser & Strauss, 1967/1999, 2004; Hallberg, 2006; Yeung, 1997). At first the researcher is simply exposed to the research area and data; without any preconceptions of what theoretical constructs may emerge; without as Allan (2003, p. 1) says, a preconceived "hypothesis". This ensures that analysis is based in the data and not on pre-existing constructs and preconceptions. Glaser (2004) is emphatic on this point: "… to undertake an extensive review of literature before the emergence of a core category violates the basic premise of GT – that being, the theory emerges from the data not from extant theory (p. 12). This resonates with Ryan's (2006) description of postpositivist research as assuming an open-ended, exploratory nature where research problems, let alone explanations for them, often are discovered. Indeed, this was my own experience of the research process, being immersed as a novice teacher in the Centre for Science Access years ago, free of preconceived notions of existing phenomena, and open to emergent understandings.

Certainly this resonates with inductive reasoning, typical of critical realist research. This is not to say that the researcher does not enter the research field without theoretical sensitivity – being steeped in the general area and literature, but without pre-conceived ideas of what may be discovered and no detailed literature review that may have developed a premature theoretical framework (Weed, 2009).

Substantive data is collected; according to Glaser (2001, p.145), “all is data” (see also Glaser, 2002b; 2004). Whatever occurs in the research area is data, be it baseline data, secondary data, experiences of the researcher him or herself (Fei, 2009), formal qualitative (such as interviewing) and quantitative data (Glaser, 1994; 2001; 2008; Glaser & Strauss, 1967/1999; Kennedy & Lingard, 2006), or even anecdotes (Fei, 2009). With respect to quantitative data in particular, Glaser and Strauss explain that it is not inappropriate to use quantitative data in the generation of grounded theory, perceived to be primarily a qualitative methodology. As these authors propose: “The freedom and flexibility that we claim for generating theory from quantitative data will lead to new strategies and styles of quantitative analysis … that will bring out the richness of quantitative data that is seen only implicitly while the focus remains on verification” (Glaser & Strauss, 1967/1999, p. 186). Lösch (2006) provides an example of how quantitative methods may be used to develop a conceptual framework whist working towards a grounded theory. In her study the properties and inter-relations of the different categories and concepts were revealed through a modification of conventional statistical tests.

Using a grounded theory methodology, data are analysed for emergent core ideas or categories that could explain variability in the data. Once the core idea is identified, new data are sought through more formal theoretical sampling, to confirm or disconfirm the elaborated concepts and the relationship between them. The process of additional data collection is done with the core idea in mind and is thus controlled by the emerging theory; this can be seen as a deductive process. Extant literature is treated as another source of data that is integrated into the theory development as the comparative process continues once the core categories have emerged (Glaser, 2004; Hallberg, 2006). This process is repeated until no new insights into the relationships are revealed (referred to as saturation), and a resultant grounded theory is defined (Glaser, 2004; Yeung, 1997). Grounded theory is thus an iterative process. Through the employment of a spectrum of methods (and/or more than one study population) compounding insights are gained that add to the richness of the understanding of the phenomenon under study; this is triangulation (Kennedy & Lingard, 2006).

The Constant "Comparative Method"

Glaser (2004) refers to the above as the "constant comparative method". Essentially this is the constant comparison of emerging codes, categories, properties or dimensions of the data and literature to establish underlying uniformity. This process generates concepts which are compared to further incidents. The articulation between these concepts is achieved through continual "memo writing" to "capture the frontier of the analyst's thinking" (p.18) and naturally leads to the abstraction of data. These memos arise through the constant comparison of indicators, during data input, reading related literature (also seen to be "data"), writing etc. and slows the process to avoid premature conclusion of theoretical frameworks and core variables. Glaser (2002a) also describes the process as "pattern naming" – by trying to find the best fit of words for a concept, the emergent social pattern is named.

As incidents are compared to incidents (through the iterative process), and then later, to categories a "core category" emerges. This core variable, which appears to account for most of the variation around the concern, becomes the focus for further data collection and emerging conceptual framework. It recurs frequently in the data, establishing a stable pattern, and as such has *explanatory* power (rather than powers of description in line with Strauss's more interpretivist version of GT). As the researcher develops several workable categories, s/he should attempt to saturate as much as possible those that have potential to explain patterns in the data. The ideational memos are sorted, integrated and reviewed to generate a conceptual framework that is theoretically complete. In establishing this best fit of concepts to a set of indicators, and the integration of (null) hypotheses, the theory is built (Glaser, 2004; Yeung, 1997). The emergent theory is used to explain in the most parsimonious way possible, and with the greatest possible scope, as much variation as possible in the phenomenon being studied. The grounded theory thus need not, and should not, describe the whole unit/substantive area, only a core process within it, the main underlying construct (Glaser, 2002a).

An Iterative Process driven by Theoretical Sampling

The “abstraction” that happens in the GT process appears to differ little from the *iterative abstraction* described by Yeung (1997). Iterative abstraction is embedded in retroduction – a general (critical) realist method which sees a movement away from the *description* of a phenomenon to a description of something that is a condition for that phenomenon (Bhaskar, 1986), that is, to abstractions of possible causes (Yeung, 1997). This refers back to Glaser’s (2002a, b) firm take that the product of grounded theory is **not** accurate description but transcending abstraction. Yeung (1997) places iterative abstraction at the heart of critical realist research. Sayer (1992) is cited by Yeung (1997) as explaining that abstractions necessarily isolate in thought only partial aspects of an object, but through systematic combination constitute concepts which “grasp the concreteness of their objects” (p.58). As such empirical evidence is systematically collected to iteratively generate abstract relations between concrete phenomena and deeper causal structures until no contradictory evidence is obtained – and empiricism per se is avoided. When the generative mechanisms are sufficiently robust to explain the concrete phenomenon, a “realistic abstraction” is said to be achieved. Should bad abstractions that suggest non-necessary relationships be made, the critical realist researcher remedies this through further theorisation and reflection which is also included in the research process. As Yeung (1997) confirms, the critical realist GT method reinforces iterative abstraction and recognises that this process provides mediation between theory and practice. The research is guided by the quest for theory and not sheer empiricism; theories of causal mechanism are grounded in concrete phenomena. Furthermore, the explanatory critique and illustration of underlying social structures afforded by GT facilitate the critical realist mission of human emancipation.

The theoretical sampling referred to above requires data to be collected according to the issues that emerge from initial and ongoing analyses. This helps to refine and develop the theoretical concepts that emerge from the analysis which contrasts with the conventional notion that successive sampling is done to increase the original sample size (Weed, 2009). GT takes time. Significant theoretical realisations come with growth and maturity both in the data and the consciousness of the researcher, as the discovery process can be slow. Rushing the process may leave the researcher conceptually and creatively depleted and result in an incomplete “thin theory” (Glaser, 2004, p. 17). The retrospective study presented here has had the advantage of time; the abstractions have been allowed a number of years to mature. Unhurried, substantive theory emergence has thus been made possible.

Grounded Theory and Quantitative Data

As has already been intimated, generating grounded theory using quantitative data has largely been unexplored (Fernández et al., 2007; Glaser & Strauss, 1967/1999, Glaser, 1994; 2008). Indeed, most contemporary grounded theory studies are the interpretivist version of this methodology (e.g. Charmaz, 2005), research conducted in the tradition of Strauss, the data primarily collected by means of interviews (e.g. Allan, 2003).

With grounded theory changing the emphasis from theory testing, verification and accuracy to theory generation, Glaser (1994, p.198) relates that many rules normally engaged when dealing with quantitative data can be relaxed (such as tests of significance), thereby bringing out the "richness" in this data. Glaser also explains that, in a similar way to developing grounded theory using qualitative methods, concepts relying on quantitative data being considered for theory generation will be found in previous descriptive or qualitative data on the same subject. Categories and properties emerge whilst collecting and analysing data, processes which are governed by theoretical sampling. It is here that both related extant literature and the historical and contextual experiences (formal and informal) of the researcher come into play (see earlier "all is data").

Secondary data (i.e. that which has been collected before the research for some other primary purpose, invariably by someone other than the researcher) (Barret in McMillan & Schumacher, 2006) is most likely to be employed when generating theory from quantitative data (Glaser & Strauss, 1967/1999, Glaser, 1994; 2008). Secondary data may be inaccurate (because of their inherently second hand nature) but where this would be a problem for theory verification, it is not necessarily problematic for the researcher wanting to generate theory, as what is relevant here are the general relationships between the properties of the data and the categories that emerge (Glaser & Strauss, 1967/1999; Glaser, 1994). Secondary data is thus particularly well suited to theory generation. On the other hand, Barrett in McMillan and Schumacher (2006) acknowledges that secondary data sets usually provide very large samples and with this improved reliability in the traditional (and statistical) sense.

Glaser and Strauss (1967/1999) and Glaser (1994) also outline how, when used to generate theory, indices used may be more “crude” or “general duty” than would be necessary with theory testing (1994, p. 201). For example, instead of having elaborate scales, simpler cruder indices are both appropriate and sufficient (an example of this in this study is the development of an inventory to gauge the motivation goals of Foundation Programme students for the Biology module in Chapter 8). This obviously has implications for instrument development. It is the view of the current author, that in attempting to develop any instrument that “works” (as Glaser would see fit), simple, traditional measures of validity and reliability may be employed. In addition, in instances where an index does not work (is not emerging in the theory), then, in Glaser’s view, the theoretical relevance of a concept should be questioned rather than the index itself (the precision of its formulation).

Cognisance also needs to be taken of the role of statistical tests of significance when generating theory. Glaser sees these tests as directing attention away from theoretically interesting relationships that, if shown to be (statistically) non-significant, would lead to them being overlooked. Indeed, weak relationships could be theoretically important. In this regard it is considered invalid when generating theory, to place too much emphasis on the statistical significance of any testing. Instead, foregrounding magnitude of effect as a measurement of association as advocated by Field (2009) and McMillan and Schumacher (2006), and demonstrated in a grounded theory study by Lösch (2006), is seen to be more appropriate and meaningful. A final point to mention is that it appears there is much scope for developing grounded theory with quantitative data: “the styles … are multitudinous” (Glaser, 1994, p. 220).

Modifying rather than Testing Grounded Theory

From Strauss’s perspective the testing of the theory is not required to confirm its status as validly grounded (Hallberg, 2006). As such, it does not seek to be generically applicable, but is theory grounded in a substantive area (Strauss & Corbin, 1998).

Citing himself, Glaser (2004 citing 1978, p.93) reiterates that the principal goal of grounded theory is not “clever *verification*” but *generation* of conceptual theory in the form of (null) hypotheses. In the tradition of Glaser though, a grounded theory study *can*, and should, extend to the testing or “verification” of these grounded (null) hypotheses to become grounded theory (Annells, 1997) using quantitative or qualitative methods. In this respect, Glaser has moved little from the tenets that he (and Strauss) originally laid down. That is, that a "theory should provide clear enough categories and hypotheses so that crucial ones can be verified in present and future research; they must be clear enough to be readily operationalised in quantitative studies" (Glaser & Strauss, 1967/1999, p.3). I would contest that it is this "verification" rather than "falsification" of null hypotheses that may push Glaserian grounded theory research uncomfortably towards positivist research (as intimated by Annells, 1997). In my opinion, recognition of the fallibility of knowledge as discussed earlier would appropriately draw this methodological approach back to critical realist postpositivism. Indeed, grounded theory has the inherent methodological mechanism to be able to respond to any new data that arises, and open the theory to modification, having taken the ever-changing world into account (Glaser & Strauss, 1967/1999; Glaser & Holton, 2005 cited by Fei, 2009). In this way, grounded theory can be seen to be a process that is still developing, open to modification, but can be presented as a momentary product (Annells, 1997; Hallberg, 2006; see also Yeung, 1997). This certainly resonates with the postpositivist reflexive acceptance of the possible "imperfection and fallibility of evidence" (Phillips & Burbules, 2000, p. 31); that warranted assertions may conflict, knowledge claims can always be overthrown and theories may be contested or modified, but those procedures employed, the evidence collected and the claims that are made, are the best available to the researcher at any given time. This "dynamic homeostatic process" where the "present is always a new starting point" is also the position adopted by those who advocate pragmatism (Johnson & Onwuegbuzie, 2004, p. 18).

This modifiability is recognised by Glaser at a further level. According to this methodologist (2002a; b; 2004, p.21) grounded theory allows the researcher to arrive at an abstract level of conceptualisation that allows underlying general social patterns to be understood; that is "a substantive conceptual theory with general implications". Glaser means that substantive theory can easily be applied to other substantive areas by the constant comparative method of modifying theory. It is possible for grounded theories to move to a more generic level of applicability through the linking of substantive areas to create more formal grounded theory as mentioned earlier (Glaser, 2004; Weed, 2009). It is this formal grounded theory that should be, according to Glaser (2002a), transcendant of time, place and people, and any one substantive area. The current research may represent a stage in the process towards more formal theory, but to assume the possibility of formal theory would be nothing short of arrogant and naive.

Mixed Methods, Grounded Theory and Triangulation

Johnson and Onwuegbuzie (2004), whilst not describing grounded theory methodology per se, suggest that the logic of mixed methods includes inductive (pattern discovery), deductive (theory/hypothesis testing) and abductive (uncovering and relying on the best of an available set of explanations) processes. As described above, these are inherent in grounded theory methodology. Grounded theory thus offers the opportunity to engage mixed methods as described by these authors, and in doing so help to break down the paradigmatic divides mentioned earlier (Chapter 2; see also Strauss & Corbin, 1998). These authors offer both mixed-model and mixed-method designs as mixed method typologies, and describe a wide scope of possible ways of "mixing". At the outset of the study presented here, a decision was taken to apply a mixed-model design that blended qualitative and quantitative approaches to the research. Specifically it is intended that this will be "quantitative-dominant mixed methods research" (see Johnson, Onwuegbuzie & Turner, 2007); quantitative methods will be foregrounded for data collection and analysis within the study that will have, overall, a qualitative approach and objective, that is grounding theory in data (mixed model design 4 of Johnson and Onwuegbuzie, 2004, p. 21).

This decision to omit qualitative methods of data collection and analysis such as interviews with relevant participants and stakeholders is acknowledged to be a limitation of the current study; it is however also seen as an opportunity to extend the research in the future in the spirit of ongoing substantive grounded theory modification as described earlier.

Mixed methods offer opportunities for corroboration and convergence of results across different approaches. This is triangulation and not only contributes to confidence in research findings and conclusions (validation), but leads to thicker, richer data, expands on the understanding of a phenomenon and can lead to the synthesis or integration of theories (complementarity) (Jick, 1979; Johnson, Onwuegbuzie & Turner, 2007). Typically, triangulation refers to the collection of data through both qualitative and quantitative methods (Cohen, Manion & Morrison, 2000); the more the methods contrast with each other, the greater the researcher's confidence in their results can be assured. Thus an explanation from more than one standpoint allows a richer analysis.

Denzin (1978) is cited by Johnson, Onwuegbuzie and Turner (2007, p. 114) as outlining four types of "multiple operationalism" (see Jick, 1979 for description of this combination of methodologies in the study of the same phenomenon): *data, investigator, theory* and *methodological triangulation*. Denzin also distinguishes within-method from between-methods triangulation, placing more value on the latter as it is seen to limit the possibility that research findings may be influenced or biased by inherent weaknesses of the study approach (artefacts of either quantitative *or* qualitative method). In addition, this author (cited by Cohen, Manion & Morrison, 2000 and Jick, 1979) extends triangulation to include *time and space triangulation* that employ multiple techniques within a given method. Jick (1979) explains that "within-method triangulation" involves cross-checking for *internal consistency* or *reliability* while "between-method triangulation" tests the degree of *external validity*. It is well recognised that convergence in triangulation facilitates both validity and reliability (Johnson, Onwuegbuzie & Turner, 2007; McMillan & Schumacher, 2006; Nieuwenhuis, 2007b; Yeung, 1997).

Evaluative Criteria for this Grounded Theory Study

Opportunities for triangulation are seen to be implicit in grounded theory (as method), given the iterative process of theory induction. Thus, as described above, opportunities also exist to establish reliability (internal consistency) through within-method triangulation. This study draws from both traditionally quantitative and qualitative notions of reliability. The "within-method triangulation" is aligned with the former, research consistency and replicability (over time, instruments and/or groups of respondents) as described by Cohen, Manion and Morrison (2000).

From a qualitative view point, reliability refers to issues of dependability and trustworthiness (Nieuwenhuis, 2007b). Healy and Perry (2000) propose that for critical realist research, opportunities for a full audit would suggest trustworthiness; this would entail providing sufficient detail of the data and results to the readers of the research to allow checking of interpretations, assertions, and for grounded theory in particular, the conceptual theory that is produced by the study. In addition to this, Weed (2009) suggests that to evaluate grounded theory research at a micro level, issues that need to be considered are internal consistency, quality, and the extent to which the research has met its own stated goals. In order for there to be internal consistency, research claiming to use grounded theory methodology must at least exhibit the iterative nature of the process (including the method of constant comparison that allows the integration of new and existing data) in a context of theoretical sensitivity and sampling (Lingard, Albert & Levinson, 2008).

Reliability is understood to be a necessary, but insufficient condition for validity (Cohen, Manion & Morrison, 2000). Internal validity seeks to demonstrate that the research data can actually sustain the explanation provided; it concerns the accuracy of the research (Cohen, Manion & Morrison, 2000) and speaks to the grounded theory criterion of "fit" as described by Weed (2009).

External validity refers to the degree to which results can be generalised (Cohen, Manion & Morrison, 2000, Maree & Pietersen, 2007, McMillan & Schumacher, 2006). In research that includes naturalistic methodology, this is interpreted as applicability, comparability and transferability. The issue of transferability is inherent in the development of grounded theory from substantive to formal as described earlier. However, it is considered that Bassey's (2001) notion of "fuzzy generalization/ prediction" is useful in this respect, particularly considering its apparent alignment with postpositivism. According to Bassey (2001), a fuzzy prediction replaces the certainty of scientific generalisation. Where a scientific generalisation may claim that "x in y circumstances leads to z" (p. 10) (or be probabilistic, "there is a p% chance that particular events (x in y) will lead to particular consequences (z)" (p. 6)), a fuzzy generalisation would propose that it is possible, that in y circumstances, x *may* lead to z (far more appropriate in the social sciences). The likelihood of this happening can be indicated by a "best-estimate-of trustworthiness", based on the researcher's judgment. Certainly this resonates with the fallibility of knowledge as understood by postpositivism. In fact Hammersley (2001), in critiquing Bassey, correctly points out that scientific and probabilistic generalisations are conditional, thus further adding to the "fuzziness" of any kind of generalisation! As such, the term "fuzziness" is a "mode of formulation" (p.223) that should characterize all generalisations.

Nonetheless, Bassey's (2001) claim that fuzzy prediction invites replication is worth considering; "… and this, by leading either to support of the statement or its amendment, contributes to the edifice of educational theory" (p. 6). With each replication of a study, the parameters can be modified, thereby reducing the "fuzziness" of the generalisation (p. 12). So too, with each iteration in the grounded theory process, the conceptual theory is better defined. This author makes reference to work by Schofield (1990) who describes generalisability as depending on the "fit between the situation studied and others to which one might be interested in applying the concepts and conclusions of that studied" (p. 8). Bassey associates this notion of validity with his concepts of relatability. I draw reference here with reliability and external validity as described above and, in particular with grounded theory notions of quality as described by Weed (2009) and Glaser and Strauss (1967/1999).

In spite of the relaxation of rules associated with quantitative data (including secondary data) referred to by Glaser and Strauss (1967/1999) and Glaser (1994) and mentioned above, every attempt should be taken to ensure reliability and validity of data that is collected and analysed. This includes consideration in the design of instruments to collect primary data, and the sources, collection techniques and verification of secondary data. Furthermore where low level statistics are employed, the appropriate considerations around statistical testing should be made (e.g. distributional and other parametric data assumptions, consideration of outliers and family-wise error). It is also acknowledged that where non-parametric techniques are used, the distributional assumptions may be relaxed (Field, 2009). Having made these assertions, it is prudent to be mindful that it is not valid to place too much store by statistical significance testing when generating grounded theory. Furthermore it is acknowledged that some techniques of data analysis will be more valid when generating theory than others.

With reference to grounded theory in particular, Glaser (e.g. Glaser & Strauss, 1967/1999; Glaser, 2004) outlines criteria to evaluate quality in terms of *fit, workability, relevance* and *modifiability*. "Fit" means that emerging categories and generated theory must fit (represent) and explain the collected data (the incidents and phenomena they represent) rather than preconceived concepts being forced upon the data. Constant comparison helps to ensure that this quality criterion is met (Weed, 2009). There are similarities here with more traditional construct validity (also described by Healy and Perry (2000) to be an appropriate quality criterion in critical realist research). As mentioned above, it is recognised that triangulation, inherent in the iterative process towards grounded theory will also facilitate quality assurance.

Furthermore, a theory “works” if it offers analytical explanations for the processes in the study context and has “relevance” if it deals with the real concerns of those involved in these processes. In addition, a grounded theory must change when conditions change. As has been mentioned, grounded theory is inherently modifiable and dynamic (Glaser & Strauss, 1967/1999; Glaser & Holton, 2005 cited by Fei, 2009). This resonates with Healy and Perry’s (2000) “contingent validity” (rather than internal validity) as being a relevant quality indicator for critical realist research. This recognises the fragile, dynamic nature of social processes that are contingent on their environment and that can be understood through a description and explanation of broad generative mechanisms.

Healy and Perry (2000) consider “ontological appropriateness” to be an important quality criterion, similar to Weed’s (2009) macro-level philosophical considerations, and believe this should be made explicit in research. Indeed this chapter is intended to serve this purpose for the current study. Within the realm of critical realist research, Healy and Perry (2000) see a demonstration of theory building to be a quality issue. They term this “analytic generalization” and since grounded theory is indeed largely that, it is deemed that the use of this methodology contributes to the quality of research conducted with a critical realist ontology (see Guba & Lincoln, 2005).

In having outlined these issues of validity and reliability, it is hoped that it is clear that this empirical, grounded theory study seeks to be rigorous in the manner in which it attempts to explore and conceptualise one particular, substantive area, namely the Life Science (Biology) entry modules at UKZN.

CHAPTER 4

A Review of the Foundation Programme of the CSA: Backdrop for Grounded Theory informed Curriculum Development in the Foundation Biology Modules

Objective 1. To provide a review of the Foundation Programme of the CSA at UKZN, and specifically the Foundation Biology module.

The following review of the Foundation Programme provides a backdrop to grounded theory development; it is a “steeping” in the immediate context of the study (see previous chapter, and specifically Glaser & Strauss, 1967/1999; Weed, 2009), the Centre for Science Access, where I found myself at the start of my research journey. It also provides a context for grounded theory-informed curriculum development in the Foundation Biology Modules to be proposed. This review was prepared as a paper[7] before its inclusion in this research, written when the author still assumed responsibility for the coordination and teaching of the Foundation Biology modules. What is recorded in this chapter thus reflects the status quo at the time it was written (see note 4), and until the end of 2011. Note that the usage of the present-tense has not been changed for the chapter.

The Educational Philosophy of the CSA Foundation Programme

The original Science Foundation Programme was conceived and carefully designed, drawing from a wide base of educational theory (Grayson, 1996). The original philosophy remains the basis of the Foundation Programme today.

Two closely interrelated theoretical constructs underlie the Foundation Programme: that of constructivism, central to which is the premise that knowledge is personally constructed or created through reflection and meaning making (Anderson, 1996; Driver et al., 1994; 2004)), and that of Vygotsky (1978) who proposed that learning was a product of social interactions. In acknowledging that to “function within the culture of university science, students need to learn the ‘social language’ of science” Grayson (1996, p. 997) and the initiators of the Foundation Programme identified strongly with social constructivism. But emphasis was also placed on the learning of the individual along the lines of the work of Ernst von Glasersfeld (e.g. 1991; 1990 cited by Grayson, 1996), who

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is commonly regarded as a radical constructivist. Typically, radical constructivism foregrounds the individual creation of knowledge (Phillips, 1995) and. recognises that all learning done by an individual passes through a filter of prior knowledge. As such, care was taken to balance the sociocultural and individual influences of learning, and to structure instructional activities accordingly to achieve desired outcomes.

Recognising that constructivist positions can be taken anywhere along several continua is important when considering the form of constructivism intended for the original Science Foundation Programme, and beyond. To this end, Phillips (1995) is most helpful. Notably, in the original writings about the Programme’s philosophy, Grayson (1996) makes no explicit mention of radical constructivism which, as Osborne (1996, p.56) notes is a deliberate attempt to depart from the traditional epistemological base which is understood to be the basis of the rationality of science. Radical constructivism, as Ernst von Glasersfeld would have it, problematises the notion of a “reality external to the cognitive apparatus of the individual knower” (Phillips, 1995, p.8). That is, since teaching, learning and knowing are necessarily part of a particular person’s experience, this reality cannot be objective (von Glasersfeld, 1991, p. xv). Consequently, the goal of “our cognitive efforts” is not to present “an objective representation of a world as it might exist apart from us and our experience” (von Glasersfeld, 1991, p. xv), that is to learn about the “absolute truth” (Treagust, Duit & Fraser, 1996), but to construct viable or useful knowledge that will help us to cope with our experienced world. Having rejected the idea of an objective reality, the radical constructivists concede that people can reach consensus in certain areas of “their subjective experiential worlds” (von Glasersfeld, 1991, p. xvi); there are agreed ways of operating, for example the consensual domains of science.

Not all are happy with this viewpoint. For example Osborne (1996) contends that the (radical) constructivist view, in emphasising the theoretical personal and social construction of reality, has led to misconceptions around, and misrepresentations of, the nature of science. Osborne (ibid.) views (radical) constructivism’s failure to present any consistent criteria for establishing the relative viability of these theories, or indeed any criteria to determine the concept of “viability”, as a great weakness.

Conversely, as Osborne points out, well established methodologies exist for Science as well as means for judging between competing theoretical descriptions (Osborne, 1996); this rationality and reliability of its knowledge is Science’s strength.

Through experimentation and acting on the world, confidence can grow in the representations of scientific entities, initially tentative theoretical speculations. Integral to the study of science, is an understanding of how this body of knowledge has been accrued (Osborne, 1996); understanding that there are many methods of achieving this knowledge, and processes for establishing its validity and reliability (such as the identification and control of variables, the generation of sound hypotheses, concepts of objectivity and fair testing, measurement of error, and the adjudication of competing theories) is vital. This does not equate to the "scientific method" associated with verificationism which is commonly understood to be able to guarantee the development of infallible knowledge (Abd-El-Khalick, Waters & Le, 2008). In this regard, Donelly (2006) alludes to the conflation by some authors of science-education writing, of realist interpretations of scientific knowledge and an "absolutist understanding of its knowledge claims" (p. 625). Indeed, it has been acknowledged that much more could be done towards teaching about the tentative nature and fallibility of science (and the ontology and nature of science on the whole) (Abd-El-Khalick, Bell & Lederman, 1998; Abd-El-Khalick et al., 2008; Donelly, 2006; Spiece & Colosi, 2000). Importantly, it has long been recognised that students who perceive science as an ongoing process of concept development adopt a deep approach to learning in comparison to those who see science as a collection of unchangeable facts and laws and whose approach is passive and characterised by rote-learning (Edmonson & Novak, 1993).

Osborne (1996), in his critique of constructivism, also points to a conflation by constructivism of the ideas of science (that have been socially negotiated) with the objects of science (the natural world), and a recognition that nature constrains scientific discourse (p. 62). In this respect he proposes instead, an ontology of "modest realism" (p.69) which, based on the work of Harré (1986), recognises the ontically stable existence of things with the understanding that our beliefs and descriptions of them are open to revision. That the ultimate "truth" of such objects remains unknown; what is known and believed about the objects of our scientific investigation is unstable relative to the existence of those objects.

Citing Hacking (1983), Osborne (1996) neatly describes this position:

… that theories and their representations attempt to refer to some reality and science progresses because these theories improve and our descriptions are enhanced. Although we can never be certain that they are accurate representations … Hacking would argue that the phrase 'as certain as we can possibly be' summarises the claims made about reality by (scientific) theories (p. 72).

In the context of the above discussion it is perhaps best to situate the Foundation Programme somewhere towards the middle of Phillip's (1995) "humans the creators versus nature the instructor" (p. 7) (knowledge as being "made" or "discovered") continuum, a position identified for Popper who saw "man as the proposer of knowledge, nature as the disposer" (Phillips, 1995, p. 9). This position reflects a form of constructivism described by Treagust et al. (1996, p. 4): without denying an "outside reality", this form of constructivist teaching and learning holds that the only possible knowledge about reality or "the world outside" is subjective. Even Driver et al. (1994; 2004) (who tended towards the more radical end of the constructivist continuum) cites Harré (1986) when explaining that scientific knowledge is "constrained by how the world is and that scientific progress has an empirical basis, even though it is socially constructed and validated" (p. 60). Indeed, one has to wonder whether the entire range of constructivist ontic and epistemic notions, for all their different theoretical arguments, do not amount to the same thing: "constructivism", as Tobin et al (1994) cited by Osborne (1996), describes it, is "a set of beliefs about knowledge that begins with the assumption that reality exists but cannot be known as a set of truths" (p. 57).

Given the above, a critical realist position has been identified as the philosophical standpoint for the Foundation Programme, not specifically identified originally by Grayson (1996) but through a personal experience and understanding of pedagogical practice and Programme philosophy over the past ten years. This pluralistic version of constructivism is deemed most appropriate for learning and teaching science in the CSA[8].

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[8] …and indeed, it is consilient that the current research takes the same philosophical view (Chapter 2; see also Venter, 2001).

Irrespective of these different notions of “reality”, according to the constructivist view of teaching and learning, the active construction of knowledge occurs whenever something is learned (Driver, 1988, Driver et al., 1994; 2004; Duit & Confrey, 1996, Northfield, Gunstone & Erickson, 1996). Knowledge is not received passively, but is constructed by the cognising student from the words or visual images they hear or see. This new information passes through the filter of a learner’s prior knowledge and experience. Consequently, when involved in this creation of meaning, what the learner already knows is of central importance (Driver et al., 1994; 2004; Duit, Treagust & Mansfield, 1996; Hewson, 1996); this resonates with Dewey’s approach to relate a child’s experiences with the subject-matter knowledge that is being learned. This take on learning is not new. Treagust et al. (1996) refer to Ausubel (1968) when explaining that “the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly…” (p. 1).

Prior or background knowledge is stored in existing mental models or schemata and used in the interpretation and assimilation of new knowledge (Anderson & Bower 1983; Driver, 1988; Driver et. al., 1994; 2004). Originally proposed by Piaget, these cognitive schemes are formed and developed through the resulting coordination and internalization from an individual’s interaction with the physical world (Driver, et al., 1994; 2004); these schemes evolve as experiences become more complex. Meaning depends on an individual’s current knowledge schemes, and in any field all future learning is influenced by initial mental schemes with learning occurring when prior schemes are modified through internal mental activity (Driver, 1988). A comprehensive background on a topic therefore suggests that well developed schemata exist as a framework for the effective construction of new knowledge (Driver, et al., 1994; 2004). Slavin (1997) highlights the importance of background knowledge in predicting student learning by saying this factor is even more important than general learning ability.

An awareness and understanding of students’ alternative points of view (their perspectives, experiences and conceptions) can lead to major reconstructions of science and mathematics knowledge, both on the part of teacher and learner, and is fundamental to improving science teaching and learning (Duit et al., 1996). As Osborne (1996) has pointed out the “shift in describing pupil errors from mistakes, of no theoretical interest, to misconceptions, changed the commonplace and unremarkable, to something significant”

(p. 63). Within this framework, formative assessment becomes crucial as a mechanism for establishing learners' needs. In addition, the amount of scaffolding required is guided by formal assessment.

Furthermore, the role of metacognition in improved conceptual change within a constructivist framework has been highlighted (Georghiades, 2000). As such, "active" in a constructivist sense, means much more than hands-on activity and class participation (Cooperstein & Kocevar-Weidinger, 2004). And indeed, an important tenet of constructivism is that learners are responsible for their own learning (Duit & Confrey, 1996). Whilst acknowledging this personal and/or social construction of knowledge, the power of experience and activity methods in the constructivist classroom are foregrounded. Moreover this approach aims at science and mathematics knowledge, not as formulae to be memorised, but as "knowledge in action" (Duit & Confrey, 1996, p.85) with the science and mathematics of daily life forming much of the content for learning.

Appropriately, facilitated practical activities supported by group discussions are fundamental to the Foundation Programme pedagogy as this teaching strategy best enhances the conceptual change (and/or growth) that occurs when new knowledge schemes are developed (see Driver et al., 1994; 2004; Duit & Confrey, 1996; Hewson, 1996).

Social constructivism views science education as a "process of enculturation" in which the "aspirant members of a culture learn from their tutors" (Driver et al., 1994, p.7; 2004). This socially mediated view of learning to be, and think like a scientist, involves being apprenticed (or socialised) into a community of science (and its ways of knowing), and making these scientific ideas and practices meaningful at an individual level (Driver et al., 1994; 2004). Knowledge construction thus goes beyond the personal level, in that learners are given access to the social knowledge systems of science; learning extends from the cognitive structures of individual knowing to the public domains of knowledge, the disciplines (Phillips, 1995). Students thus access a disciplinary discourse. They learn to identify with, and be a part of, a particular community.

In terms of the Vygotskian view, this cognitive development as a social, communicative process, is one that can only take place in the individual's Zone of Proximal Development (Lajoie, 2005; Fernández, Wegerif, Mercer & Rojas-Drummond, 2001). As such, a primary role of the Foundation Programme staff is one of sensitive facilitator as students are supported in their attempts to carry out tasks that they initially would find too difficult to carry out by themselves (see Duit et al., 1996; Lajoie, 2005; Venter, 2001). Here, the teacher's role is to provide the physical experiences where learning may occur, and to mediate learning through collaborative dialogue and encouraging reflection. In this way, learning is "scaffolded" by the teacher (Driver et al., 1994; 2004; Lajoie, 2005); learners are actively guided to perform a task through process modelling, questioning and the offer of assistance. Scaffolding is further extended to motivational scaffolding (providing students with feedback on how they are doing) (Pintrich & Schunk, 2002). In acknowledging that scaffolding is temporary and dynamic, the expert facilitator, over time, reduces the amount of help and the learner becomes more independent – as a learner develops competence the facilitator withdraws support (Lajoie, 2005). Through interaction with students in tutorials and in the laboratory, the Foundation Programme teaching staff (including senior student demonstrators for the latter) is guided as to how much support (scaffolding) is needed.

Fernández et al. (2001) highlight the potential that collaboration between students with similar levels of conceptual understanding (a symmetrical relationship in contrast to the asymmetrical expert – novice one described above), has for encouraging learning (see Bruffee, 1995 for distinction between collaborative and cooperative learning). Shared knowledge, "created through language and joint action" results from investment in a collaborative, goal directed task (Fernández et al., 2001, p.42). The success of this depends on the appropriateness of the communication strategies employed by the participants; scaffolding is mutually provided through appropriate dialogue. Through interpersonal communication (between peers), Foundation Programme student learning is thus encouraged as they compare and share ideas and attempt to resolve conflicting understandings. Integral here is the Dewian central focus of community and the Vygotskian role of language in transferring social experiences to the individual (see Phillips, 1995 and Venter, 2001). Small group work and whole class discussions facilitate this in the Foundation Programme. Furthermore, the intensive, non-elective nature of the year-long programme promotes the kind of collaborative learning community described by Tinto (1998) which has been found to deepen student's levels of academic involvement and promote student persistence.

The social dimension of learning is reinforced in the established formal (although not compulsory) mentorship programme set up to assist students who are struggling. These mentors are senior students, commonly those who have passed through an access programme themselves. Informal study groups with caring senior students, often those who are the above mentioned mentors or demonstrators, are also regularly established. Slonimsky and Shalem (2004) refer to these networks as academic communities of practice and cite Bourdieu (1990) when describing the role of this "social and cultural capital" (p. 96) in the mediation of enculturation into university. Tinto (2005) identifies this kind of support as being a primary condition for student success at university. This is related to the benefits described by this author of the involvement of students in educational communities, central to which is collaborative learning (see also Tinto, 1998).

Thus the Foundation Programme is best seen as representing a position again midway along a constructivist continuum; this one the "individual psychology versus public discipline continuum', a place again, also occupied by Popper (Phillips, 1995). Indeed, Grayson and colleagues (Grayson, 1996) were careful to ensure a balance between the "sociocultural and individual influence on learning"; this continues to be central to the Foundation Programme.

Principles and pedagogy

The organisation of the classroom and the nature of instructional activities are obviously vitally important in ensuring the achievement of the desired kind of learning described above, in particular the knowledge that learners construct and how they structure their knowledge, as well as the cognitive (in addition to the metacognitive) processes they develop. Primarily, the ultimate responsibility for learning is seen to lie with the student as they actively and purposively participate in the learning process. Knowledge is not "out there", to be transmitted and absorbed; it is personally and socially constructed. Thus the constructivist pedagogical approach is student centred in that subject matter is used as a vehicle for interactive engagement with the students (Duit & Confrey, 1996). That is not to say that pedagogy should exclusively include "negotiate, facilitate, mediate, co-construct" (and other such constructivist actions) (Osborne, 1996, p. 67) at the complete expense of "telling, showing and demonstrating". As Obsorne (1996) has pointed out constructivist teaching is seldom associated with the latter, and this may be accounted for by the common belief that the traditional objective view of knowledge leads to a transmission style of teaching and learning as memorizing and recall (see also Venter, 2001, p. 87). Of course this is not necessarily so, but it is the (typically) constructivist conflation of the nature of science (production of new scientific knowledge), and on the nature of teaching and learning science (how old knowledge is learned in the classroom) that is responsible for this misconception. Teachers of science would do well to take cognisance of this, and adopt a more pluralistic pedagogy (Abd-El-Khalick et al., 2008; Osborne, 1996; Venter, 2001).

Learning in the Foundation Programme is experiential and skills-based for the development of lasting cognitive and practical skills; as Cooperstein and Kocevar-Weidinger (2004) point out, "…constructivist learning moves from experience to knowledge and not the other way around" (p.141). The active exchange and negotiation of ideas between learners and teacher, and between learners challenges students' preconceptions about science, learning, and teachers (particularly as all-knowing authorities). In this respect, the teaching and learning about the nature, and processes of science is particularly important; acknowledging the limitations of scientific knowledge and appreciating that there is no one standard method for scientific inquiry are challenging for students.

Peer teaching and collaborative learning are actively encouraged (in Vygotskian terms, this enables students to create a zone of proximal development for one another as mentioned above). Whilst this environment is conducive for productive, constructivist learning, this can be an uncomfortable experience for learners, and a challenge for teaching staff. It is important in this respect to encourage learners to become more self regulatory and autonomous, and not so dependent on the teacher for an assessment of progress or success (Duit & Confrey, 1996).

Teaching for transfer is a key instructional principle and this is facilitated by both a broad integration of the discipline modules, and also integration of the different components, and tasks within each module. Specific content relevant to each subject is chosen as a vehicle for the development of useful scientific skills rather than for its own sake, the focus therefore is on the processes rather than the products of science. Teaching of content and skills in the Programme have, from the outset, been intertwined; at the time of the Programme's inception, this was in stark contrast to the way many support programmes had been run in the past in South Africa (Grayson, 1996). The reasoning and practical science skills are taught explicitly and are not assumed to be “picked up along the way”. Furthermore, content in the curriculum is deliberately restricted to allow room for this explicit inclusion of such skills, and for the promotion of conceptual development. Great care is taken by staff to identify and explicate the thinking, reasoning and practical skills that a student will need to learn to prepare him or herself for the discipline of study to be pursued; that will enculture him or her into the discipline of science (for example Appendices G and H detail the skills developed in the Foundation Biology module).

The active engagement in a task designed for some learning outcome is central to the pedagogy of the Programme and consequently a large proportion of learning tasks are experiential. The instructional approach is primarily skills based and highly interactive and consequently the number of lectures is restricted. However, although there are many who believe lectures to be ineffectual, (for example, Ramsden, 2003; Mazur, 2009, and see discussion above) this remains a common mode of teaching in mainstream at UKZN, certainly in the Life Sciences. To accustom students to this, and so they may gain experience in note-taking in class, the contact sessions in some topics are specifically designed and presented as lectures. Moreover, the content learned in these lectures form the basis of more experiential learning in tutorials and practicals. In this respect, the pedagogy has changed somewhat from the original approach laid out in Grayson (1996).

The bulk of the theoretical component however, predominantly takes the form of tutorials. These contact sessions with academic staff take place in groups of no more than 40; optimally a ratio of about 30 students to 1 staff member exists for the science modules, making personalised attention possible. In Mathematics and Communication in Science, students are arranged in even smaller tutorial groups (tutor/demonstrator to student ratio here is also about 1 to 12). Students are expected to prepare for the majority of these tutorials; discussion and peer group interaction promote active participation in the learning process, followed by individual consolidation through written exercises. Many of these exercises are assessed to give students regular feedback (both summative and formative) and also to help the students keep pace with each module. It is intended that this regular assessment should help students develop the important metacognitive skill of monitoring their own understanding, and thus taking responsibility for their learning. Students also learn accountability through the regular submission of work for assessment.

The metacognitive dimension of learning is developed both in the science modules and in the counselling component. In the former, activities such as concept mapping (see for example Novak, 1996), and summarising are designed to encourage reflection on what has been learned, and to help make connections between the different concepts explored, both of which encourage meaningful learning. The counselling component includes opportunities to develop students' metacognitive skills by exploring different study skills and encouraging them to reflect on their own approaches to learning, and studying.

Much of the contact time is spent actively engaging with subject matter in the science laboratory (for the biology, chemistry and physics modules). The teaching method in laboratory sessions is "hands-on"; students work in small groups of no more than twelve with one appointed demonstrator. A guided inquiry style of instruction is used here; inadequate background knowledge is assumed whilst learning is scaffolded, the processes of science are emphasised, and the development of scientific reasoning and thinking skills are explicitly foregrounded. These laboratory sessions are long enough (at least 1½ hours, but more often 3 hours) to allow an unhurried pace for teaching and learning. This provides students with the opportunity to develop their practical skills soundly and build confidence in a laboratory; both are significantly lacking when they arrive at University, and without which they would not cope in mainstream. Where possible, learning is made accessible and meaningful in that the subject matter is related to the students' lives; learning tasks are thus authentic (see also Cooperstein & Kocevar-Weidinger, 2004).

It is here in the laboratory that students' academic literacy is extended to the nature and processes of science. They get to conduct experiments following the step by step approach typical of the "scientific method" that is universally adopted for the teaching of scientific processes (Spiece & Colosi, 2000). However, and most importantly, this routine is supported by tutorials where the processes followed, results achieved and conclusions drawn are discussed in context of the broader philosophical views of science taken by the Programme put forward earlier. As such, students appreciate that science is more complex than the scientific method "steps", that different interpretations of the same set of results can be made, that science is an ongoing endeavour that refines our understandings of the world, and that science is fallible (see also Abd-El-Khalick, Bell & Lederman, 1998).

As well as learning how new knowledge is produced, these activities illustrate that scientific knowledge is socially negotiated, and judged within a framework of existing knowledge. They learn that there are established venues of communication and critique within the scientific community which serve to enhance objectivity and reliability of the knowledge generated. For example, laboratory work is followed closely by scaffolded report writing. It is acknowledged that the relationship between science and society could receive more attention in the Programme's curriculum.

Effort is made to ensure that the learning environment is conducive to optimisation of learning, achievement of outcomes, and building of student confidence. Initially the pace of teaching and learning is slow so that students do not feel overwhelmed and disempowered. As the year progresses, the pace increases to build up the students' stamina and speed to prepare them for mainstream study. Mechanisms are put in place to help students to work hard and consistently. These include a full, but well-structured timetable (and strict adherence of modules to notional study hour requirements), attendance monitoring, insistence on punctuality, and timeous submission of assignments. This is particularly important for the Foundation students, many of whom have come from schools where teaching has been intermittent and little has been expected of them in the past. Expectations of student performance are made explicit from the start and, the processes and criteria for assessment are made transparent. Feedback from staff with respect to performance in practicals and assessments is frequent, timeous, comprehensive and constructive. Slonimsky and Shalem (2004) outline the importance of this when outlining the process of mediation in teaching for meaningful learning. Constant monitoring of students across all the modules occurs to establish academic standing, and those identified at risk are counselled (although there are some staff who have concerns that this might build dependency and defeat the ends of self regulation, personal communication with Foundation staff). In addition to this and the timetabled counselling component, the counseling staff offer unlimited consultation to students should they seek it. Students also experience separate computer training.

Notably, with respect to student (and learning environment) monitoring, Tinto (2005) believes that, first-year student attrition can in part, be explained by universities' low expectations of students, the result being that students do not study enough. This is certainly not the case here. Furthermore, this author sees student monitoring and feedback as important in promoting student persistence.

These pedagogical features are in line with SAQA (2000) which requires that educational provision is made to support students from diverse/disadvantaged backgrounds (see also Luckett (1998)).

Programme's critical and developmental outcomes. The Centre for Science Access School Plan (last revised in 2005) lists general outcomes common to the foundation modules that are reflective of those originally conceived for the Foundation Programme (Grayson, 1996). These are based very heavily on the critical cross-field and developmental outcomes of the National Qualifications Framework (NQF) (SAQA, 2007) Realistic outcomes are set in order to facilitate the building of self confidence in students. The following outcomes are implicit in the School Plan (2005) documents:

- Students are expected to be able to communicate effectively; they are expected to improve their language (listening, reading, comprehension and writing) skills, follow written and verbal instructions, be able to articulate and communicate their understandings, and participate in class.
- Students are expected to be able to *collect, analyse, organise and critically evaluate information and demonstrate problem-solving skills*. They should be able to engage in critical thinking, link topics and draw comparisons and conclusions, and apply knowledge to interpret new information. Cognitive skills showing application of logic should be demonstrated and *basic numeracy skills* developed and applied in a variety of contexts.
- Students should also have achieved a level of *mathematical competence* that will provide them with a foundation to build upon in mainstream. Similarly, they should have developed *conceptual understanding in selected scientific disciplines* that can form the basis for further study in these areas, and be able to apply these scientific concepts in a variety of familiar and novel contexts. Related to this is that students are expected to have a working (and practical) knowledge of the *variety of methods employed in science* such as experimentation, hypothesis testing and report writing.
- It is expected that by the end of the programme students should be able to demonstrate a basic understanding of the world as a set of related systems by recognizing that *problem-solving contexts do not exist in isolation*. In this respect students should have developed an *holistic view* of each module, have

an appreciation of how the theoretical and practical work in each module is related, and have generic science process skills that they are able to transfer from one discipline context to another.

- They are expected, by the end of their foundation year, to be able to *organise and manage themselves and their activities responsibly and effectively*. Students need to have developed a responsible attitude towards learning by being required to behave appropriately in the laboratories, by having to prepare for tutorials and practicals, having to submit work regularly and on time, and by performing independent tasks.
- Directly related to this is that students should also be able to *manage information* effectively as in developing note-taking skills as well as keeping ordered sets of notes for all modules.
- *Students are also expected to have the ability to work collaboratively*. Whilst often not explicitly assessed, many tasks and assignments cannot be completed without successfully working together. The completed tasks are then assessed.

Further key outcomes are the development of *life skills* (such as positive coping skills and self-reliance), the ability to reflect on and explore a variety of *strategies to learn* more effectively, and an *awareness of career and education opportunities*.

Science Foundation students are assessed formally and informally to determine their competence in each of the outcomes stated. These methods include written assignments (some completed in tutorials, others independently outside contact time), laboratory reports, by observation in the laboratory and on field excursions, and also orally, for which feedback is given as mentioned above. These ‘low-stakes’ assessments contribute to a continuous assessment component; students are therefore initiated into the practice of science by being given many opportunities to meet the criteria of academic practice before final formal assessment in the examinations.

The Foundation Biology module

The Foundation Biology modules are housed in the School of Biological and Conservation Sciences of the University of KwaZulu-Natal (now the School of Life Sciences). The main purpose of the modules is to scaffold the acquisition and development of practical and cognitive science process skills, and the biological content and concept knowledge required for undergraduate Life Science modules.

Developing an awareness and appreciation for biological issues is also central to the module. Indeed, registration for the Foundation Programme as a whole is usually extrinsically motivated, this being a programme that provides access to mainstream studies. Another source of extrinsic motivation is the enormous amount of pressure that is often placed on the students by communities back home, in many instances those living in poor, rural areas, who invest in the students in the hope of having a successful and educated member of the family. This, and the fact that students cannot elect to omit any module in their foundation year, has particular implications for student motivation. For example those students who have aspirations to study engineering have low levels of motivation for biology. This can lead to students adopting a surface and mark driven approach to learning (Kirby & Downs, 2007).

Certainly, love of learning, confidence in learning and the development of cooperative attitudes are important affective objectives (Krathwohl, Bloom, & Masia, 1964). In a subject such as biology which does not enjoy high enrolment numbers among black African students, it is important to assess student attitudes and perceptions of the subject and try to build on instructional goals related to attitudes, values and appreciation. Past research into the backgrounds of the Science Foundation students has touched on these issues (Kirby & Downs, 2007), and movements have been made to stimulate interest and motivation in biology (for example, inviting motivational speakers, concentrating on making field trips enjoyable, educating demonstrators about problems faced by the students). Indeed, as a consequence of the financial constraints typically experienced by Access students (Barnsley, 2002; 2008a), many have not been exposed to Science (and in particular Biology) in an extra-curricular manner e.g. television programmes, field trips or leisure time in nature reserves (Downs, Inglis & Akhurst, 1996; personal experience), and have had little access to non-academic science books to stimulate a genuine interest in the field (Parkinson, et al., 2007; 2008).

Previous research has suggested that a significant challenge for learning and teaching in the Programme is the students’ inadequate background knowledge in mathematics and natural history in particular (and therefore the absence of adequate schemata as described earlier) (Downs, Drummond, Akhurst & Inglis, 2001; Downs, et al., 1996). The fact that they are English Second Language speakers compounds this background knowledge deficiency (Feltham & Downs, 2002). In addition, students experience problems cognising, understanding and expressing themselves in English (Downs, 2005; Feltham & Downs, 2002; Parkinson et al., 2007; 2008). Furthermore, on enrolling in the Foundation Programme, most students have no practical experience of science, or computer and library skills, their previous schools having had no such facilities (see note 9 and recorded in the selection process by the selection officer of the Centre (personal communication, March, 2009)).

To this end, the curriculum is designed to allow students to engage with topics in an interactive way whilst acquiring knowledge and understanding of basic biological content and concept knowledge, an appreciation of biological systems, and an holistic understanding of basic scientific principles. As such, the curricular content acts as the vehicle for the constructivist learning; this is arranged in a series of developmental topics so that each unit prepares students for subsequent ones. These units include: *Life* (Unit 1), *The Science of Biology* (2), *Cell Biology* (3) (including two themes, cells as the basic unit of life and the continuity of life), *Life's Diversity* (4), *Ecology* (5), and *The History of Life* (6) (including the fossil record, evolution of life, natural selection, and an introduction to plant and animal evolution). A comprehensive outline of the cognitive and practical skills afforded by these units is provided in Appendices G and H. The application and transfer of skills is reinforced through the close articulation of the tutorial and practical components as evident in these appendices.

Both cognitive and practical skills are developed in the laboratory where, for at least half of the year, a marine theme serves as the vehicle for the curriculum. The intention here is not to teach content pertaining to the marine environment, but to illustrate biological principles and gain generic skills through this theme. This aspect of the curriculum is outlined in detail in Downs et al. (2001) and Feltham and Downs (2002).

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9. see Chapter 1.

Tasks in the laboratory are designed to be as authentic as possible, thus presenting students with opportunities to engage with the practices as would an established academic. This, and the sequencing of concepts taught, as Slonimsky and Shalem (2004, p.90) point out, mediate (what these authors refer to as) “distantiation and appropriation”, activities necessary for academic depth within a particular practice. In addition to the tutorial and practical components of the module, students are exposed to tasks that require them to practise their reading and writing skills. Regularly, students are expected to submit written answers to questions set on brightly coloured, illustrated text on the marine environment. These readings are accessible, intended to be enjoyable, and aim to encourage a culture of recreational reading in the students. In addition these exercises offer students a valuable learning experience as many of the questions integrate concepts learned in tutorials, and written feedback offers guidance where misconceptions prevail. These assessment tasks are also designed to build confidence in learning as they are very low risk. However, because each of the assignments carries so few marks, many of the students elect not to do them (or plagiarise from other students). As has been shown by Kirby and Downs (2007), Foundation Programme students generally show reluctance to take responsibility, motivate themselves and engage in self-regulated learning (see Boud, 1995; Boud and Falchikov, 2006). They have difficulty assessing their own performance or ability, their naivety and inexperience hampering their ability in this regard.

Student performance in the Foundation Biology module has not been particularly good during the years explored in the current research (Table 4). This table outlines the percentage of students passing, and the mean mark obtained (%) in Continuous Assessment (CAM), and theory and practical exam components of the final mark for Foundation Biology (2006-2009). A final mark[10] of 50% or more is needed to proceed into the LES stream of mainstream. The mean final student mark for the Foundation Biology module is indeed average, hovering around 50%, and in the sense that it is mediocre. That the pass rates for the module are relatively high for this mean, suggests that many of the students going into the mainstream Life Science modules are borderline. Given this, it is very important to establish how successful those students who **do** pass the Foundation Programme are in a core mainstream Biology module for which their access year supposedly prepares them.

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[10] This final mark comprises a class record mark (50%) and a final theory exam result (50%). The class record mark includes a year-long continuous assessment component, mid-year test results and performance in a practical exam. Students write the final theory examination in November.

Having outlined the Foundation Programme's philosophy and pedagogy, and gained insight to the Foundation Biology module in particular, the next objective of this research is to gauge the mainstream performance of the Foundation Programme students relative to those that are augmenting first year, and those that have gained direct entry. As such, questions about the efficiency of this alternative Access route into the Science Faculty of UKZN can be better answered. This is dealt with in the next chapter.

Table 4

Percentage of Students Passing, and Mean Mark Obtained (%) in Continuous Assessment (CAM), Theory and Practical Exam Components of the Final Mark for Foundation Biology (2006-2009)

	CAM		Theory exam		Practical exam		Final mark	
Year	% pass	mean	% pass	mean	% pass	mean	% pass	mean
2009 (*N* = 88)	75	54	18	37	56	49	67	50
2008 (*N* = 79)	81	56	33	46	63	53	68	52
2007 (*N* = 60)	77	55	43	46	72	54	68	51
2006 (*N* = 81)	68	52	20	39	51	51	48	47

Note. Final mark details reflected include supplementary exam results. Students need to attain at least 40% in their final mark in November to qualify to write supplementary exams. If granted, students must write both theory and practical supplementary exams even if they have passed one of these in November. Continuous assessment marks (CAM) and, Theory and Practical exam results are those achieved in November and exclude supplementary exam results. All means reflected are a percentage; % pass indicates proportion of cohort that passed.

CHAPTER 5

Attempt to meet Objective 2: An Initial Grounded Theory Emerges

Performance of Access Students Relative to Direct Entry Students in a First-Year Biology Module

Objective 2 To gauge the mainstream performance of the ex-Foundation Programme students relative to those that are augmenting first year, and those that have gained direct entry. As such, questions about the efficiency of the alternative Access routes into the Science Faculty of UKZN can be better answered.

Note: The initial grounded theory that emerges from the data analysis is written in italics towards the end of the current chapter. For subsequent chapters the developing grounded theory appears after each section where results are presented.

Rationale for Method

McInnis (2001) relates that research concerned with the first-year university experience is largely focussed on issues of equity in much the same way as it was in the 1970s (albeit with changes in the impetus for research, with universities nowadays responding to the pressures of accountability and efficiency rather than a need to measure sociological and psychological differences in student experiences). Similarly, McInnis (2001) points out that the same problems and tensions associated with research methodologies exist as they did more than thirty years ago.

Pascarella and Terenzini (1998) highlighted the changing face of universities, describing how by 1991 their study on 2 600 American colleges no longer reflected representative findings as the student body had changed so much since the inception of their study in the late 1960s. They cite criticism of their study by Stage (1993): “Ironically, just as analysis of the experiences of college students reached an apex in terms of quantitative technique and vigour, the population of interest began shifting” (p. 151). Similarly in Australia, where the remainder of the bulk of research on issues surrounding higher education has taken place, McInnes (2001) reports that by the early 1980s there was an emerging diversity in the university system with students commencing their studies from diverse cultural and academic backgrounds and preparation levels. The consequence has been a growing trend in research to become more in-depth, analytical and ethnographic, in contrast to the more large-scale quantitative, measurement driven studies that had been typical until then. These studies are not, in the main, intended to provide generalisable findings (McInnes, 2001). Indeed, as McInnes (2001) explains, a more diverse student population will have a greater diversity of outcomes which means greater complexity for researchers "in the questions they frame, and the methods they use" (p.110). Pascarella and Terenzini (1998) are very clear about the need for diversity in the approaches to examining the first-year student-university interface in the face of increasing student diversity.

By these historical, international standards, higher education research, particularly on issues surrounding innovations and intervention strategies aimed at first-year students, is an emerging field in South Africa with limited publications (Lourens & Smit, 2003). This is not entirely surprising given the context of apartheid prior to 1994, and it was only in 2001 that the new Government indicated that research into the decline in retention rates in South African universities warranted investigation (DOE, 2001b). Indeed, the high dropout rates are alarming (Macgregor, 2007). Furthermore, the great deal of instability in the secondary school system in this country which has contributed to student underpreparedness (already discussed in Chapter 1; see also Blaine, 2008; 2009; Matric results, 2007; Sapa, 2009), adds to the issue in terms of access and selection into higher education in this country. Access Programmes, as also indicated previously, have become not only a popular mechanism for redress and massification, but, by design, are innovative intervention strategies for those students who go on to mainstream study.

McInnes (2001) predicted that "for countries just shifting towards mass participation, … presented with particular problems in the face of policy demands for resource efficiency, … comparative studies will become more popular, prompted partly by scholarly curiosity, but mainly by benchmarking imperatives" (p. 111). Furthermore, McInnes (2001) indicates a clear need, internationally, for systematic research on the effectiveness of the "many and varied innovations and intervention strategies aimed at improving the first-year experience … on which to base judgements about the effectiveness of these programmes" (p. 112). The role of Alternative Access programmes can surely be included here. For a South African example, Lourens and Smit (2003) refer to the national call on higher education institutions to interrogate, for their local context, the factors affecting retention rates and student performance (see DOE, 2001b).

It is against this backdrop, and in context of the immediate milieu that I found myself (as described in the previous Chapter), that my focus turned to quantitatively comparing the performance of the Alternative Access students (particularly those who have completed the Foundation stream) with those directly admitted to mainstream.

Methods to Collect Data

Permission to conduct the research described in this chapter, and to use the relevant data stored on the University electronic systems relating to students' school results, demographic information and university results was requested from the relevant authorities. Permission was duly granted by Professor Deo Jaganyi who was at the time, Acting Dean of the Faculty of Science and Agriculture and the Acting Director for Centre for Science Access (Appendix I). Permission was also granted by Professor Kevin Kirkman, in his capacity as Head of the School of Biological and Conservation Sciences (Appendix J). As Dean of Students, Professor Trevor Wills granted permission to the University's Division of Management Information (DMI) to allow access to student's records (Appendix K). Excel files of the relevant data were forwarded to me from DMI although these data were primarily accessed through the Student Management System (SMS) and the Examinations Results Schedules (ERS) to which I had access through my formal teaching position in the University. In terms of grounded theory methodology, this would be termed secondary data (Glaser & Strauss, 1967/1999, Glaser, 1994) (see Chapter 3).

Ethical clearance for the research to be conducted was granted at the end of September, 2009. This clearance was reapproved for the purposes of a doctoral study in March, 2012 (Approval number HSS/0655/09D) (Appendix L). At the time the data were conducted, ethical considerations were adhered to by ensuring that data analysis and results did not require any personal information to be revealed about any particular student. Once full data collation was complete, student numbers were removed from the data set. Thus, once collated and cross-checked, the data was entirely anonymous.

Final BIOL 101 marks. BIOL 101 is one of the first core modules studied in the first year of a B.Sc. degree. Each cohort includes some students who have successfully completed the Foundation Programme in the previous years, some students who are enrolled in the Augmented Programme, and a large number of students who meet Faculty (post 2011, College) entry requirements without requiring additional support. The 2007, 2008 and 2009 mainstream cohorts are included in this study.

For all results presented the following abbreviations apply: ex-Foundation Programme (ex-FP), Augmented Programme (AP), direct access English Second Language (DA-ESL) and direct access English First Language (DA-EFL).

Students' continuous assessment marks (CAM), theory and practical exam marks, and final marks, **after supplementary exams** for the BIOL 101 module, were accessed through the Student Management System (SMS). The CAM for 2007 and 2008 was weighted 40% of the final mark and was calculated using continuous assessment marks earned through the semester (three tests contributed to 50% of the CAM, eleven practical write-ups contributed the remaining 50%). The practical and theory exams contributed 20% and 40% respectively to the final mark. In 2009, the practical exam was converted to a test and contributed 10% to the CAM. Three tests (equivalent to those written in 2007 and 2008) and 11 practical reports each contributed 20% to the CAM. The balance of the final mark in 2009 was made up by performance in the theory exam (50%). In order for students to be granted a Duly Performed certificate (DP) that would allow them to write the final exams for the module, they needed to have attained at least 40% in the CAM component (Faculty of Science and Agriculture 2008, 2009 Handbooks).

The theory papers in 2007 and 2008 had a similar format: multiple choice questions contributed 40% of the paper and short answer questions contributed the balance of 60% of the paper. The theory paper of 2009 was of a different nature, 75% of the paper being allocated to multiple choice questions and only 25% to short answer-type questions. There were no essay-type questions in the 2007, 2008 or 2009 theory papers.

Biographical data. By referring to records on the Student Management System (SMS), students were identified as being either ex-Foundation Programme (had completed the Foundation Programme prior to enrolling in BIOL 101, usually the year before), Augmented Programme (enrolled in BIOL 195, refer to Chapter 1), or direct access English Second Language (ESL) and English First Language (EFL) students. This data is captured from student application and registration forms onto the university Integrated Tertiary Software (ITS) system which is then downloaded on the SMS. Students will thus have identified themselves as having English as their first or second language.

Only South African nationals were included in the analysis. This is because most international students complete their schooling in their country of origin, and not only are the schooling systems different and it is difficult to establish parity across the education systems, but the school history data for these non-South African students is most often absent on ITS system of UKZN. In addition only those students who achieved their DP certificates and were allowed to sit the final exams were included in the analysis. Consequently 247 of the whole cohort of 266 students were included in the 2007 data (only four of those excluded from the analyses had not achieved their DP). Similarly 20 registered students were excluded from the 2008 data set (eight of whom had not achieved their DP), i.e. 244/264 students included. In 2009, of the 406 registered, 390 were included in the data set, 10 having not achieved their DP certificates, the balance being international students with no school performance records.

School history data. Data pertaining to each student's total Admission Points Score (APS) in the 2007 and 2008 mainstream cohorts were collected from the SMS system, and cross-checked with the ERS. Appendix A outlines the calculation of the total APS for those students who had written the Senior Certificate prior to 2008. The term "matric score" refers to the composite (total) APS that includes all six school-leaving subject results. If a seventh Senior Certificate subject was passed with a symbol of at least 'E' on HG or 'D' on SG, a bonus of 2 points is added to the APS (UKZN, 2009). Where a discrepancy in scores was found to exist between the SMS and ERS, the APS was re-calculated in the first instance.

Initially, the research intended to analyse only the 2007 and 2008 mainstream cohorts (see p. 108) so APS data was not collected for the 2009 mainstream cohort until later (see Chapter 6).

Methods to Analyse Data

Given that one of the main personal objectives for embarking on this research was to familiarise myself with inferential statistical analyses (and overcome my personal trepidation of statistics in general), data analysis was conducted as comprehensively as possible under the guidance of Field (2009). Particular attention was paid to exploring the characteristics of the data and conformation of data with assumptions underlying the parametric tests employed. Specific attention was paid to the assumption of normality of the sampling distribution and/or residuals (Kolmogorov-Smirnov tests used with visual checking of Q-Q plots, skewness and kurtosis values) and homogeneity of variance (Levene's test).

Testing of differences between means was primarily conducted using independent t-tests and one-way analysis of variance (ANOVA). Testing of differences was done after the removal of outliers as suggested by Field (2009). Where assumptions were violated which necessitated repeated testing, Bonferroni adjustments were made to the criterion for significance (to $p = 0.01$) to control for familywise error. Where ANOVAs were conducted in presence of heterogeneity of variance across the student categories, equality of means was tested using Welch's robust test in place of an *F*-ratio. Post hoc tests employed were Hochberg's GT2 test where assumptions of equality of variance were met (suitable for different sized groups, Field, 2009, p. 375), and Games-Howell where this assumption was found to be violated.

Given the postpositivist framework of this research and the employment of grounded theory methodology, the emphasis of effect sizes of the differences between means over the significance of these differences was deemed appropriate (see also Lösch, 2006). For *t*-tests, Pearson's correlation coefficient r was used to measure the magnitude of an observed effect, using benchmarks laid out in Field (2009, p. 57), where large effects are indicated by $r = 0.5$; medium effects, $r = 0.3$, and small effects, $r = 0.1$. For ANOVAs, omega squared (ω^2) was taken as an unbiased estimate of r (Field, 2009, p. 389). For post hoc comparisons for independent groups, Cohen's d was indicated as a measure of effect size as suggested by Field (personal e-mail communication). These values were calculated using an on-line effect size calculator available at http://www.uccs.edu/~faculty/lbecker/. Benchmarks used are laid out in Cohen (1988, p. 25), where large effects are indicated by $d = 0.8$ or more; medium effects, $d = 0.5$, and small effects, $d = 0.2$. In terms of grounded theory methodology, these effect sizes were recognised, and utilized, as codes in the generation of concepts.

The theory and practical exam results were dealt with using Multivariate Analysis of Variance (MANOVA) followed by discriminant analysis. Assumptions of equality of variance and covariance matrices were met in 2007, but not in 2008 necessitating a natural log transformation of the data. Pillai's Trace was used to search for differences across the four student categories in their Practical and Theory Exam Marks (Field, 2009, p. 601). All analyses were conducted using the SPSS Base software (version 15 for Windows) (SPSS Inc, ver. 15, 2006).

BIOL 101 Final Mark: Results

Difference in performance across cohorts. For the following analysis, a “cohort” refers to the student enrolment in a particular year. A “student category” refers to one of the four groups of students identified in each cohort: the ex-Foundation Programme student group, the group of Augmented Programme students, or the English Second Language, or English First Language student groups given direct access to mainstream.

Initial analysis using Factorial ANOVA revealed violation of the assumption of homogeneity of variance across the 2007 and 2008 cohorts, $F(7,470) = 3.29$, $p < 0.005$. No interaction effect was found to exist, but rather a significant difference in magnitude across the two years. On average, students performed better in 2007 ($M = 57.82$, $SE = 0.56$) than in 2008 ($M = 52.16$, $SE = 0.62$), $t(476) = 6.77$, $p < 0.001$, $r = 0.3$ (two-tailed). Given these results, the student cohorts were dealt with separately in all subsequent analyses.

Figure 2 illustrates both the aforementioned heterogeneity of variance and generally weaker student performance in 2008; lower quartile values of 44% and 53% were achieved in 2008 and 2007 respectively. Lower mean final mark scores in the BIOL 101 module were achieved by all four student categories in 2008 than in 2007 (Figure 3a). These findings are despite a slightly higher mean matric score in all but the Foundation group of students in 2008 than in 2007 (Figure 3b).

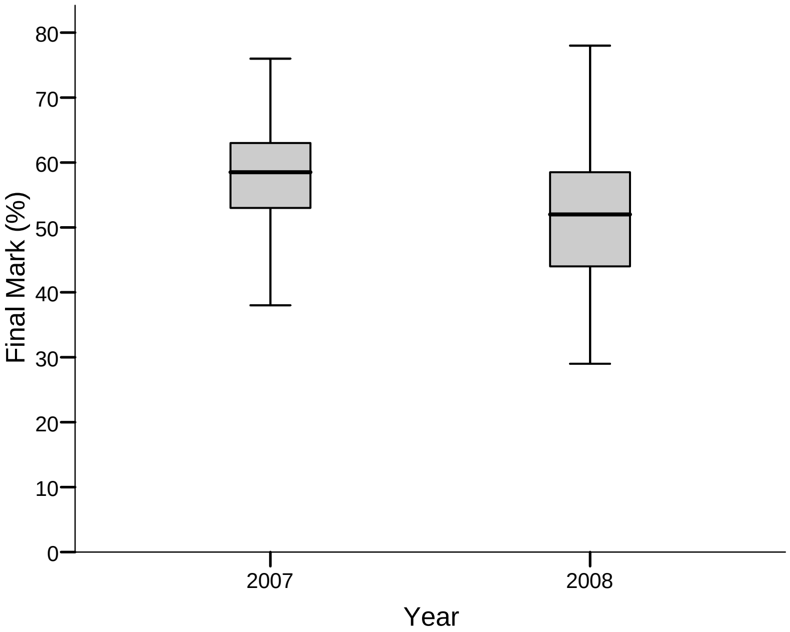

Figure 2. Distribution of final marks in BIOL 101 for 2007 ($N = 234$) and 2008 ($N = 244$) student cohorts. The tinted box indicates the inter-quartile range; the bold horizontal line indicates the median. (This applies to all subsequent box- and whisker plots).

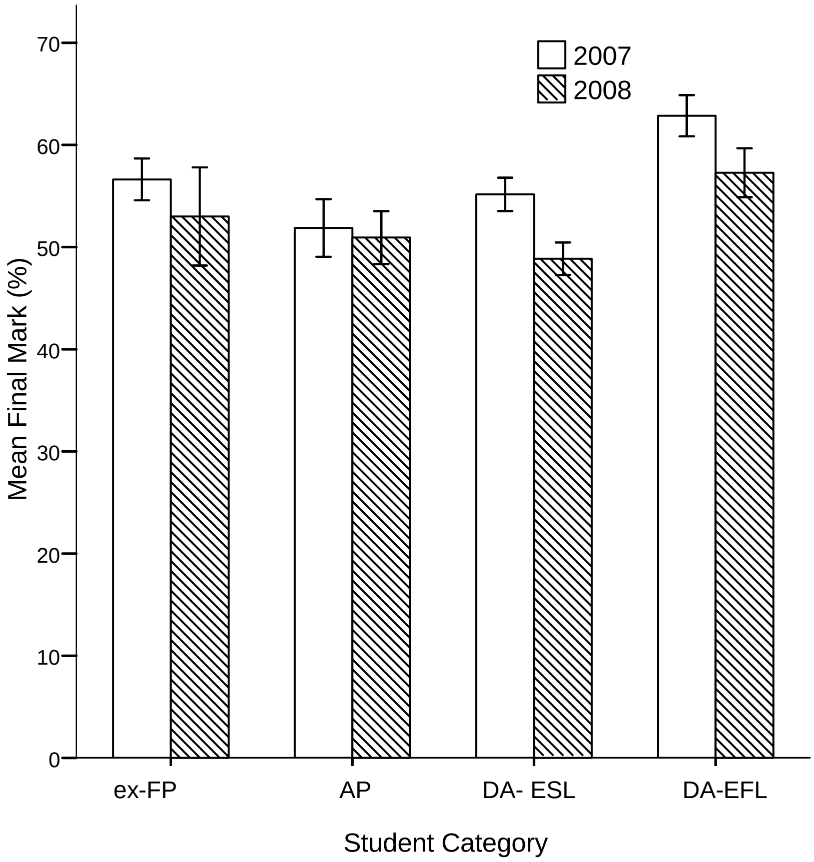

Figure 3a. Mean final marks (+ 2*SE*) in BIOL 101 for ex-Foundation Programme (ex-FP, *n* = 28; 13), Augmented Programme (AP, *n* = 31, 46), direct access English Second Language (DA-ESL, *n* = 117, 106) and direct access English First Language (DA-EFL, *n* = 71, 79) student groups in 2007 and 2008.

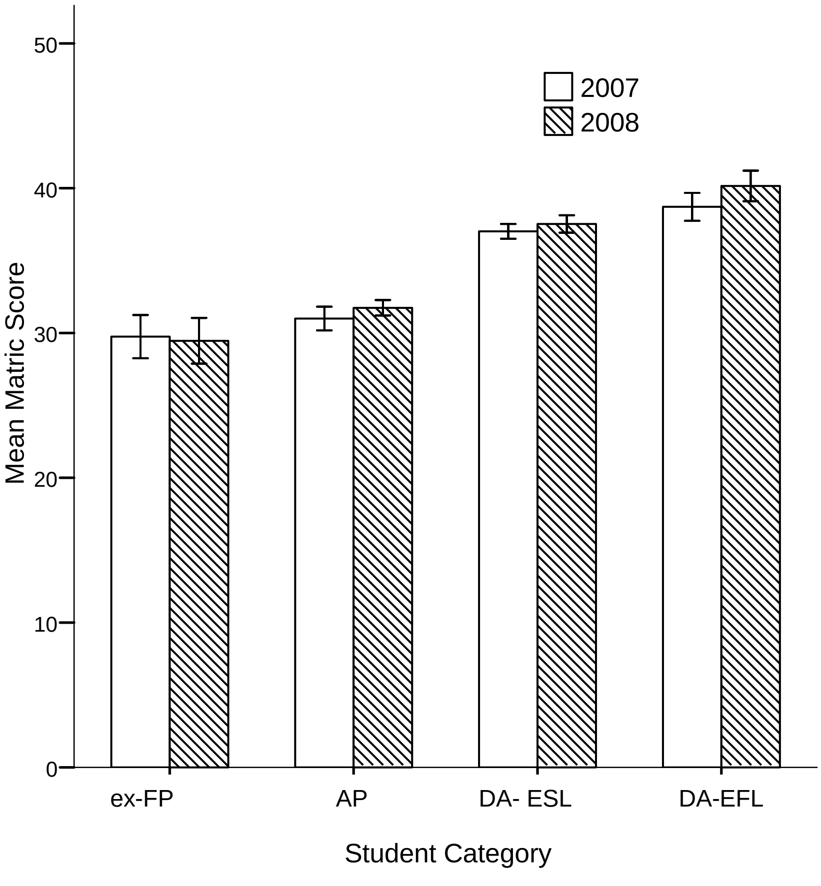

Figure 3b. Mean matric score (+ 2*SE*) for ex-FP (*n* = 28, 13), AP (*n* = 31, 46), DA-ESL (*n* = 117, 106) and DA-EFL (*n* = 71, 79) student groups in 2007 and 2008.

Student performance in 2007. Performance of the 247 students included in the analysis of the final marks for BIOL 101 in 2007 is summarised in Table 5. The ex-Foundation Programme group exhibited the smallest amount of variability in their final mark scores, even though a large amount of variability was to be seen in the matric score of this group. By comparison, the Augmented Programme and direct access ESL student groups were found to be very variable in their final mark scores in spite of a fairly tight range of matric score used as University-entry criteria. With outlier scores replaced by values calculated by adding two times the standard deviation to the mean (of each respective student category) as described by Field (2009, p. 153), the distribution of final marks and matric scores can be compared across categories of student (Figures 4a and 4b respectively).

Table 5

Matric Scores and BIOL 101 Final Marks for the Student Categories in 2007

	Matric Score				BIOL 101 Final Mark Scores (%)			
Student category	Min	Max	Mean (± *SD*)	Variance	Min	Max	Mean (± *SD*)	Variance
ex-FP (*n* = 28)	21	38	29.75 ± 3.94	15.53	44	71	56.54 ± 6.11	37.30
AP (*n* = 31)	28	35	31.19 ± 1.99	3.96	36	65	51.87 ± 7.85	61.59
DA-ESL (*n* = 117)	29	45	37.00 ± 2.66	7.05	31	75	55.11 ± 8.95	80.08
DA-EFL (*n*= 71)	30	50	38.63 ± 4.07	16.55	38	87	62.93 ± 9.10	82.64

Note. Data presented include outliers. Three outliers were each identified in the Foundation and direct-access English First Language student groups for BIOL 101 final mark and in the direct-access English Second Language group for matric score. One outlier in the DA-ESL group was identified for the final mark. For statistical analyses these outlier scores were replaced by converting back from a z-score as described by Field (2009).

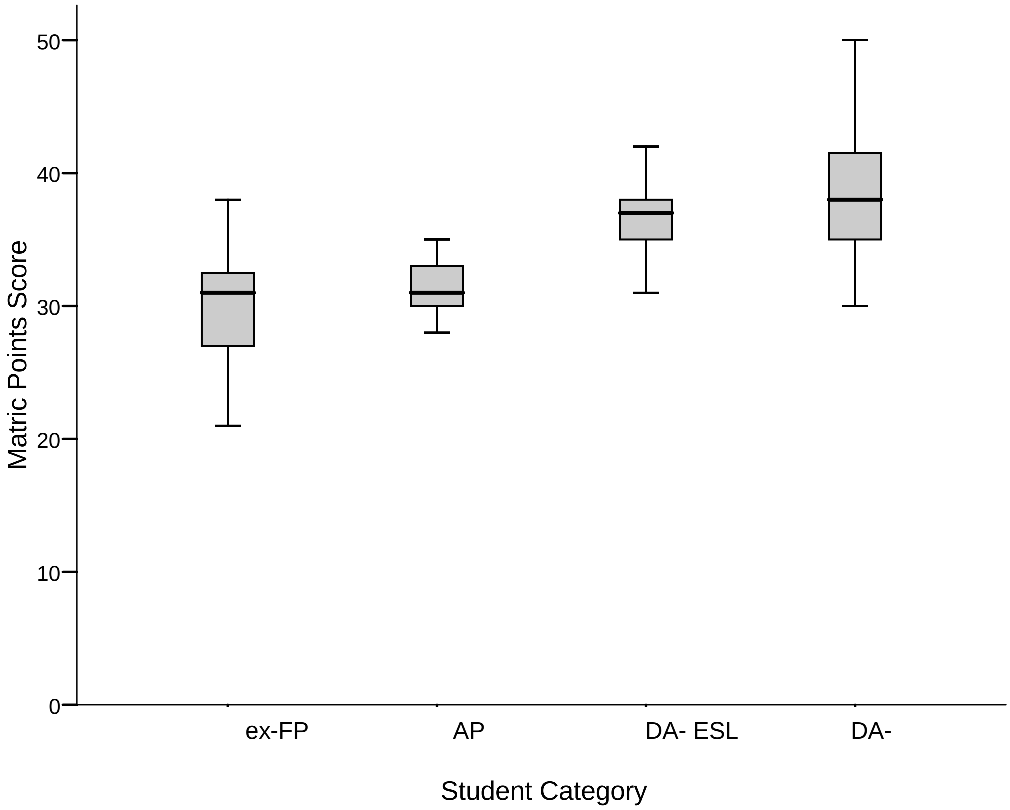

Figure 4a. Distribution of 2007 matric scores for ex-FP (*n* = 28), AP (*n* = 31), DA-ESL (*n* = 117) and DA-EFL (*n* = 71) student groups.

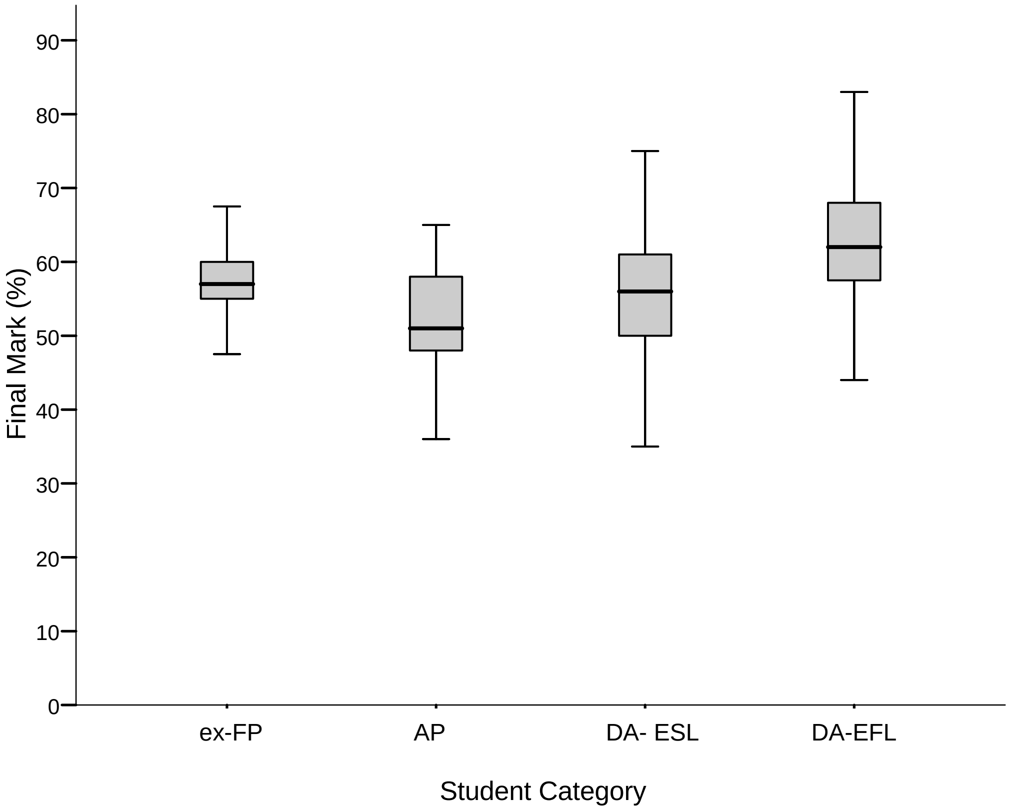

Figure 4b. Distribution of final marks in BIOL 101 in 2007 for ex-FP (*n* = 28), AP (*n* = 31), DA-ESL (*n* = 117) and DA-EFL (*n* = 71) student groups.

Given that there was heterogeneity of variance in matric score across the categories of students, $F(3,243) = 11.84$, $p < 0.001$, equality of means was tested using Welch's robust test. This revealed a very large difference (highly significant) across the student categories, $F(3, 77.38) = 94.06$, $p < 0.001$, $\omega = 0.70$. Similarly, in the absence of homogeneity of variance across the four categories in the final mark for BIOL 101, $F(3, 243) = 2.78$, $p < 0.05$, a significant difference between the categories of student was found to exist here (albeit only medium sized effect); $F(3, 86.23) = 17.12$, $p < 0.001$, $\omega = 0.41$. Games-Howell post hoc test results for matric score are given in Table 6. Post hoc tests for final mark scores (Table 7) reveal that, in spite of their lower entrance scores, the Foundation and Augmented Programme students performed as well as the direct access ESL students. It must be noted that the mean final Foundation Biology mark of the 28 ex-Foundation Programme students in their foundation year was fairly weak at 52%.

Table 6

Differences in Matric Score across Student Categories in 2007

Student Category		Sig.	95% Confidence Interval Lower Boundary	95% Confidence Interval Upper Boundary	Cohen's *d*	Direction of difference
ex-Foundation	Augmented	*0.314* N/S	-3.66	0.77	0.4	ex-FP = AP
	DA-ESL	*<0.001 ****	-9.34	-5.11	2.2	ex-FP < DA-ESL
	DA-EFL	*<0.001****	-11.24	-6.53	2.2	ex-FP < DA-EFL
Augmented	DA-ESL	*<0.001****	-6.91	-4.65	2.6	AP < DA-ESL
	DA-EFL	*<0.001****	-9.01	-5.87	2.3	AP < DA-EFL
DA-ESL	DA-EFL	*0.013**	-3.06	-0.26	0.5	DA-ESL < DA-EFL

Note. Marked differences are significant at $p<0.05$. Analysis conducted after outliers were replaced. It must be noted that a significant difference was also found to exist between groups **containing outliers** for matric score, $F(3, 78.67) = 92.81$, $p < 0.001$, $\omega = 0.69$, post hoc tests (in the absence of equal variances) revealed group differences as above.

Table 7

Differences in Final Mark in BIOL 101 across Student Category in 2007

Student Category		Sig.	95% Confidence Interval		Cohen's *d*	Direction of difference
			Lower Boundary	Upper Boundary		
ex-Foundation	Augmented	*0.041**	0.14	9.37	0.7	ex-FP > AP
	DA-ESL	*0.680* N/S	-1.99	4.91	0.2	ex-FP = DA-ESL
	DA-EFL	*<0.001****	-10.01	-2.46	0.8	ex-FP < DA-EFL
Augmented	DA-ESL	*0.194* N/S	-7.61	1.03	0.4	AP = DA-ESL
	DA-EFL	*<0.001****	-15.57	-6.41	1.3	AP < DA-EFL
DA-ESL	DA-EFL	*<0.001****	-11.07	-4.33	0.9	DA-ESL < DA-EFL

Note. Marked differences are significant at $p<0.05$. Analysis conducted after outliers were replaced. It must be noted that while a significant difference was also found to exist between groups **containing outliers** for final mark, $F(3, 243) = 16.86$, $p < 0.001$, $\omega = 0.40$, Hochberg's GT2 post hoc tests (in the presence of equal variances) revealed no significant difference between Foundation and Augmented student groups. Other group differences were significant as above.

Student performance in 2008. As in 2007, the matric scores for the two Access groups in the 2008 BIOL 101 cohort were considerably lower than either the English First or Second Language student groups (Table 8) given direct access. The range of matric scores in the ex-Foundation Programme student group was less in 2008 than in 2007 (10 and 17 respectively) and consequently the variance of scores in this year was reduced (Figure 5a). Within the context of significant inequality of variances, $F(3, 240) = 16.20$, $p < 0.001$, a robust test again revealed highly significant differences in mean matric score across the student category (Welch $F(3, 52.67) = 117.30$, $p < 0.001$, $\omega = 0.69$). Games-Howell post hoc tests (Table 9) revealed highly significant differences between all student categories, except for the ex-Foundation and Augmented Programme student groups. Although this latter pair-wise comparison was not significant, it did however represent a large-sized effect ($d = 0.9$).

In spite of these significant differences in matric score, Games-Howell post hoc tests for final BIOL 101 mark revealed no such significant difference between the ex-Foundation Programme student group and either the First or Second English Language students (Table 10). These 13 ex-Foundation students had fared fairly well in their Foundation year, achieving an average mark of 58%. The above is in context of a significant (although only medium sized) main effect of student category on final mark differences, Welch $F(3, 50.83) = 11.36$, $p < 0.001$, $\omega = 0.4$. The variance in final mark was greater in 2008 than in 2007 in all, but the direct access ESL student groups; the range in particular for the Foundation and Augmented groups was greater in 2008 than in 2007 (Figure 5b). As in 2007, the variance in final mark score across the groups was significant, $F(3, 240) = 3.52$, $p < 0.05$.

The bottom quartiles for the Augmented and DA-ESL students were somewhat lower than those for the Foundation Programme and DA-EFL groups suggesting much weaker tails in the two former groups of students (Figure 5b).

Table 8

Matric Scores and BIOL 101 Final Marks for the Student Category in 2008

	Matric Score				BIOL 101 Final Mark Score (%)			
Student category	Min	Max	Mean (± *SD*)	Variance	Min	Max	Mean (± *SD*)	Variance
ex-FP (*n* = 13)	23	33	29.46 ± 2.85	8.103	38	68	53.00 ± 8.66	75.00
AP (*n* = 46)	28	35	31.74 ± 1.82	3.31	29	73	50.93 ± 8.77	76.86
DA-ESL (*n* = 106)	33	47	37.53 ± 3.10	9.59	29	68	48.86 ± 8.17	66.70
DA-EFL (*n* = 79)	32	50	40.15 ± 4.70	22.05	38	81	57.28 ± 10.63	113.08

Note. There were no outliers in either the matric score or the final mark data sets.

Table 9

Differences in Matric Score across Student Category in 2008

Student Category		Sig.	95% Confidence Interval Lower Boundary	95% Confidence Interval Upper Boundary	Cohen's *d*	Direction of difference
ex-Foundation	Augmented	*0.066* N/S	-4.68	0.13	0.9	ex-FP = AP
	DA-ESL	*<0.001 ****	-10.49	-5.64	2.7	ex-FP < DA-ESL
	DA-EFL	*<0.001****	-13.31	-8.07	2.8	ex-FP < DA-EFL
Augmented	DA-ESL	*<0.001****	-6.84	-4.74	2.3	AP < DA-ESL
	DA-EFL	*<0.001****	-9.96	-6.87	2.4	AP < DA-EFL
DA-ESL	DA-EFL	*<0.001****	-4.21	-1.04	0.7	DA-ESL < DA-EFL

Note. Marked differences are significant at $p < 0.05$.

Table 10

Differences in Final Mark in BIOL 101 across Student Category in 2008

Student Category		Sig.	95% Confidence Interval Lower Boundary	95% Confidence Interval Upper Boundary	Cohen's *d*	Direction of difference
ex-Foundation	Augmented	*0.873* N/S	-5.59	9.72	0.2	ex-FP = AP
	DA-ESL	*0.389* N/S	-3.16	11.45	0.5	ex-FP = DA-ESL
	DA-EFL	*0.406* N/S	-11.84	3.28	0.4	ex-FP = DA-EFL
Augmented	DA-ESL	*0.522* N/S	-1.90	6.06	0.2	AP = DA-ESL
	DA-EFL	*0.003***	-10.94	-1.75	0.7	AP < DA-EFL
DA-ESL	DA-EFL	*<0.001****	-12.15	-4.69	0.9	DA-ESL < DA-EFL

Note. Marked differences are significant at $p < 0.05$.

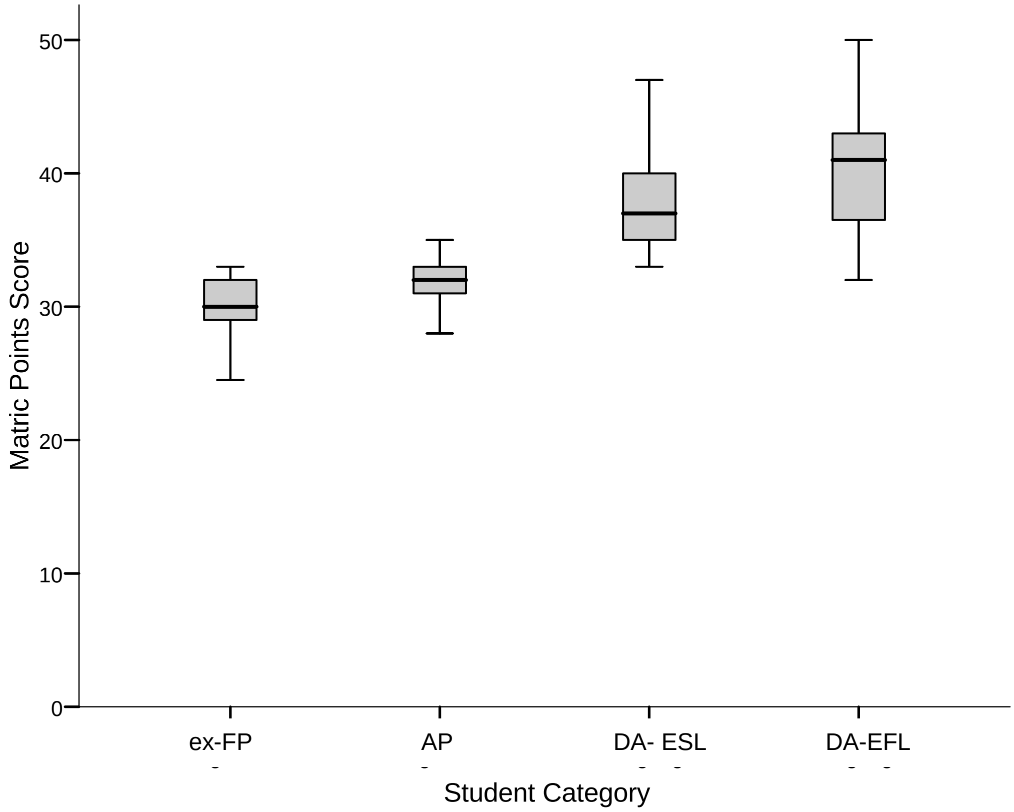

Figure 5a. Distribution of 2008 matric scores for ex-FP (*n* = 13), AP (*n* = 46), DA-ESL (*n* =106) and DA-EFL (*n* = 79) student groups.

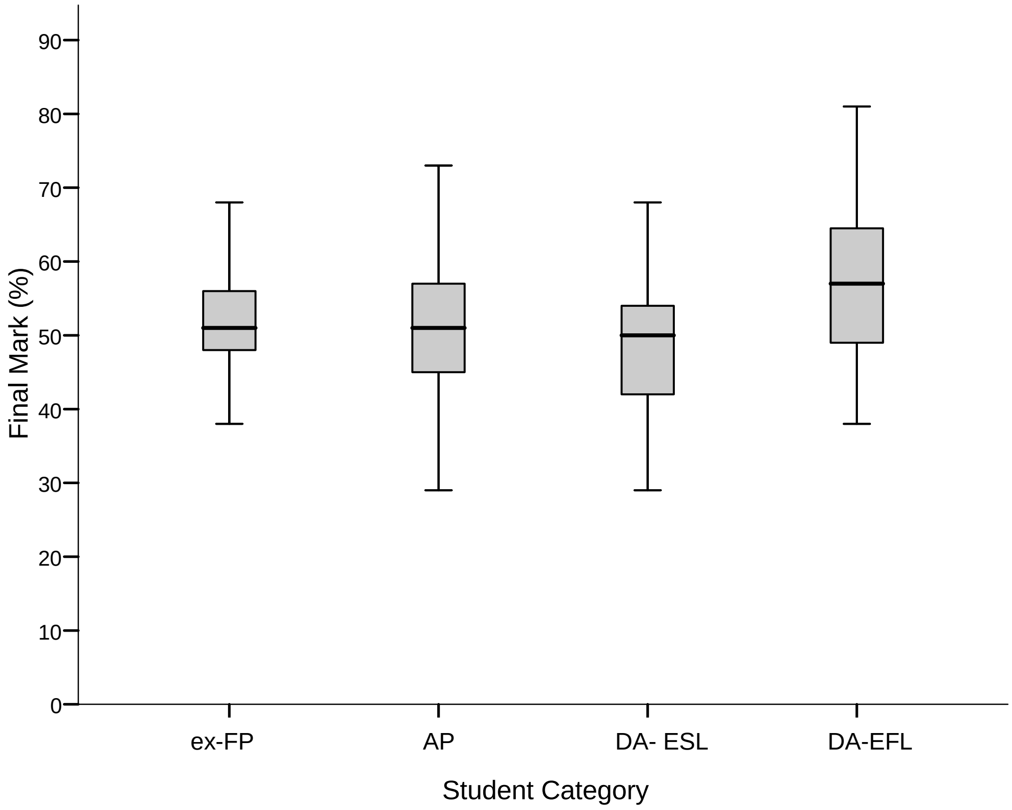

Figure 5b. Distribution of final marks in BIOL 101 in 2008 for ex-FP (*n* = 13), AP (*n* = 46), DA-ESL (*n* =106) and DA-EFL (*n* = 79) student groups.

Having established that ex-Foundation students were indeed faring well in the core mainstream module relative to the other categories of students, as indicated by their final mark, it appeared judicious to further establish which of the components of the module, were most influencing this overall result. In other words, to establish which of the mainstream challenges their foundation year had best prepared them for (and conversely which, if any, they did not perform well in), the final mark was disaggregated, and the BIOL 101 CAM and exam results were further analysed separately.

BIOL 101 Continuous Assessment Mark (CAM): Results

Given that t-tests between cohorts were calculated for the final mark, CAM, and both exams, a Bonferroni adjustment was made to the criterion for significance (to p = 0.01) to control for familywise error. This adjustment goes some way to avoiding the dangers of making a Type 1 error (Field, 2009). A significant difference was found to exist between the continuous assessment marks of the two cohorts, (M = 59.46, SE = 0.56; M = 55.36, SE = 0.56 for 2007 and 2008 respectively), $t(476)$ =5.21, $p < 0.001$, (two-tailed). However, this effect was found to be small (r = 0.23). Indeed, all four categories of student performed better in their CAM in 2007 than in 2008 (Figure 6).

In 2007, four outliers were identified in the ESL student group; two particularly high achievers and two scores that were considerably lower than the bottom quartile. Adjusting these outliers had no effect on the significant difference between student categories that was found to exist; $F(3, 243) = 24.07$, $p < 0.001$, $\omega = 0.47$. With equality of variances across groups established in 2007, $F(3, 243) = 2.36$, $p > 0.05$, Hochberg's GT2 post hoc tests found that significant differences existed only between the DA-EFL student group and the other three groups, $p \leq 0.001$ for all three, d = 0.91, 0.88 and 1.21 for ex-Foundation Programme, Augmented Programme and DA-ESL student groups respectively.

Results were somewhat different for the Continuous Assessment Mark in 2008. There was considerable variance across the groups, $F(3, 240) = 8.07$, $p < 0.001$, and no outlying scores. A robust test revealed highly significant differences in mean CAM across the categories of student (Welch $F(3, 49.66) = 18.73$, $p < 0.001$, $\omega = 0.64$). Games-Howell post hoc test results are given in Table 11. Even though the differences between the

Foundation student group and both the Augmented and DA-EFL groups are not significant, the effect size for these two pair-wise comparisons suggest the latter groups of students achieved considerably higher continuous assessment marks than the Foundation students in 2008. By contrast, the Foundation Programme and the DA-ESL groups reflected very similar CAM results in this year.

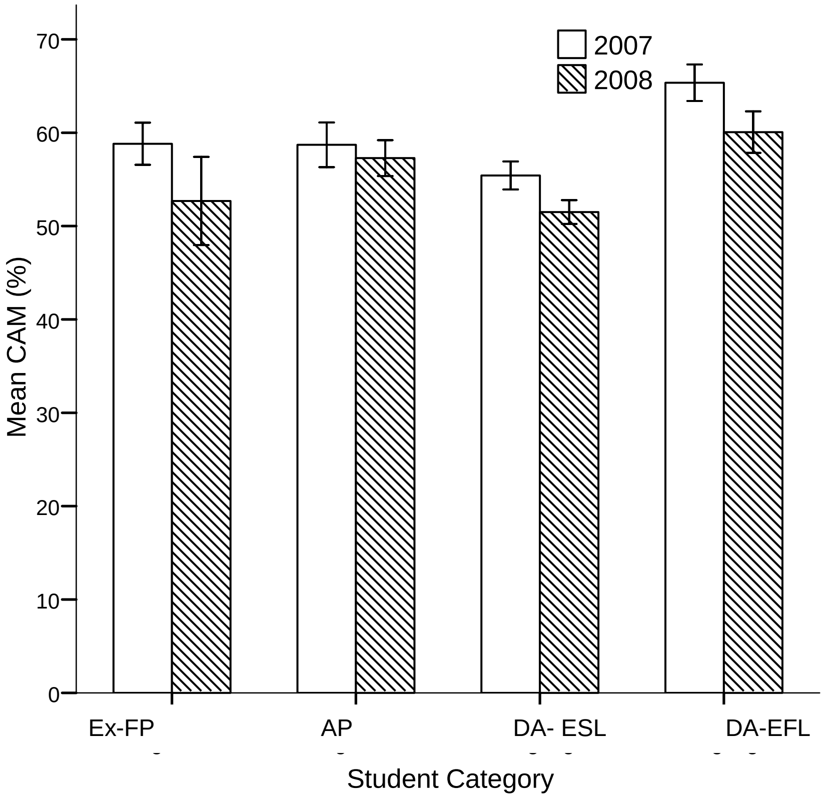

Figure 6. Mean continuous assessment marks in BIOL 101 (CAM) (± 2*SE*) for ex-FP (*n* = 28, 13), AP (*n* = 31, 46), DA-ESL (*n* = 117, 106) and DA-EFL (*n* = 71, 79) student groups in 2007 and 2008.

Table 11

Differences in Continuous Assessment Marks for BIOL 101 across Student Category in 2008

Student Category		Sig.	95% Confidence Interval		Cohen's *d*	Direction of difference
			Lower Boundary	Upper Boundary		
ex-Foundation	Augmented	*0.309* N/S	-11.88	2.70	0.6	ex-FP ≤ AP
	DA-ESL	*0.956* N/S	-5.88	8.36	0.2	ex-FP = DA-ESL
	DA-EFL	*0.051* N/S	-14.76	0.02	0.8	ex-FP ≤ DA-EFL
Augmented	DA-ESL	*<0.001****	2.82	8.84	0.9	AP > DA-ESL
	DA-EFL	*0.237* N/S	-6.61	-1.05	0.3	AP = DA-EFL
DA-ESL	DA-EFL	*<0.001****	-11.93	-5.29	1.03	DA-ESL < DA-EFL

Note. Marked differences are significant at $p < 0.05$.

BIOL 101 Practical and Theory Exams: Results

A Bonferroni correction was again applied to the significance levels when testing for differences in exam performance across cohorts. Performance in the practical exam across the cohorts was found to be significantly different (at $p< 0.01$) with the 2007 students achieving, on average, a much higher mark ($M = 69.84$, $SE = 0.65$) than those in 2008 ($M = 56.80$, $SE = 0.72$), $t(476) =13.47$, $p < 0.001$, $r = 0.53$ (two-tailed). This was true for all four categories of student (Figure 7). In addition, there was a significantly greater amount of variance in the practical exam in 2008 than 2007, $F(1,476) = 5.56$, $p <0.05$. Only three outliers were identified prior to analysis; the retention of these in their original form had no effect on results.

By contrast, there was homogeneity of variance in the theory exam marks across the cohorts, $F(1,476) = 0.21$, $p = 0.65$, and no overall significant difference was found between the two years, ($M = 48.76$, $SE = 0.77$; $M = 48.05$, $SE = 0.72$ for 2007 and 2008 respectively), $t(476) =0.67$, $p = 0.51$, $r = 0.03$ (two-tailed). A number of extremely low and unusually high marks were identified before analysis, but these had no effect on results. The lowest score in both 2007 and 2008 was 12.5% for the theory exam. Although no overall difference existed across the two cohorts, both the Access student groups appeared to perform better in 2008 than in 2007 (Figure 8).

In line with the treatment of final and continuous assessment marks, and given the significant difference that was found to exist in the practical exam mark, the 2007 and 2008 cohorts were analysed separately using Multivariate Analysis of Variance followed by discriminant analysis. Assumptions of equality of variance and covariance matrices were met in 2007, but not in 2008 necessitating a natural log transformation of the data.

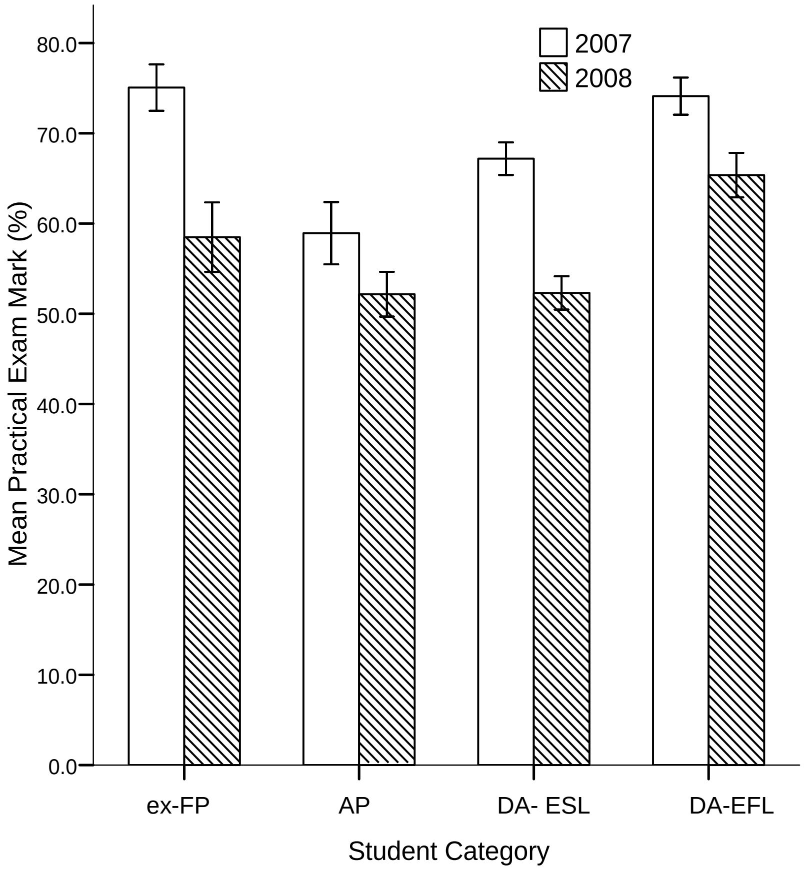

Figure 7. Mean practical exam marks in BIOL 101 (+ 2*SE*) for ex-FP (*n* = 28, 13), AP (*n* = 31, 46), DA-ESL (*n* = 117, 106) and DA-EFL (*n* = 71, 79) student groups in 2007 and 2008.

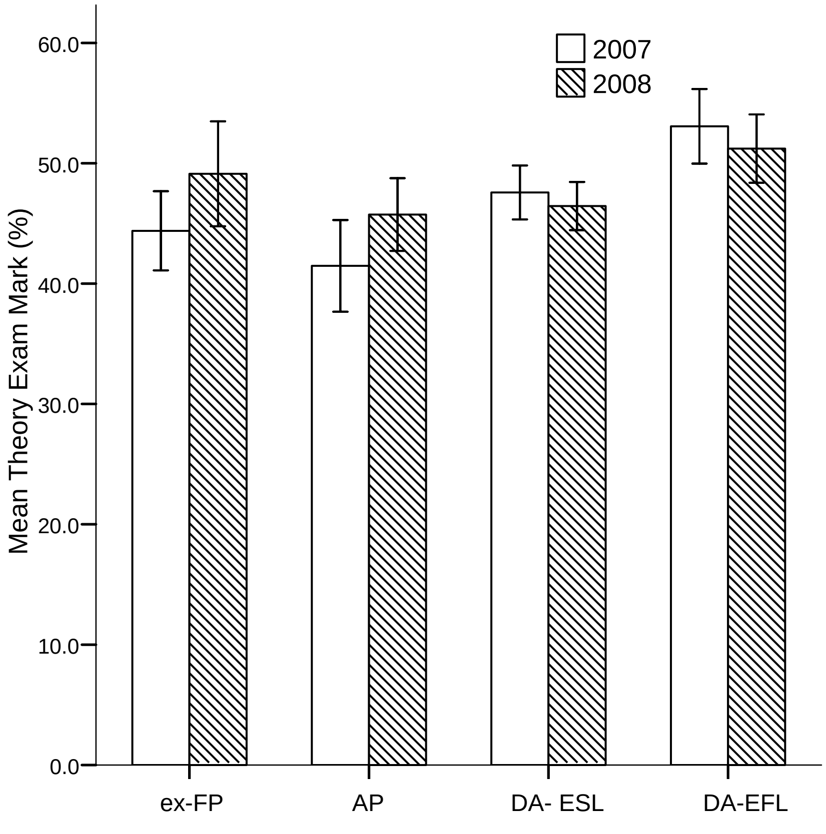

Figure 8. Mean theory exam marks in BIOL 101 (+ 2*SE*) for ex-FP (*n* = 28, 13), AP (*n* = 31, 46), DA-ESL (*n* = 117, 106) and DA-EFL (*n* = 71, 79) student groups in 2007 and 2008.

Student performance in 2007. Ex- Foundation Programme students, on average, gained the highest practical exam marks in 2007 with half of the students concentrated around 75.5% (Figure 9). Greater variances in this exam were also found in all three other student categories. The Augmented Programme students performed poorly with a quarter of the students in this group achieving less than 51.5% (relative to 70%, 61% and 67.5% in the Foundation Programme, direct access ESL and EFL groups respectively).

Both Access student groups performed poorly in the Theory Exam compared to the direct access English First and Second Language students (Figure 10). The spread of the marks in the ex-Foundation group however was less than the other three groups, with the direct access ESL group in particular exhibiting some very poor performances.

Using Pillai's Trace, significant differences were found to exist across the four student categories in their practical and theory exam marks, V=0.32, $F(6, 486) = 15.19$, $p < 0.001$. The MANOVA was followed up with discriminant analysis which revealed two discriminant functions. The first function explained 82% of the variance (canonical R^2= 0.25); the practical exam mark was loaded highly on this function ($r = 0.97$ for first and $r = 0.25$ for second function). The second function explained 18% of the variance (canonical $R^2 = 0.07$). The theory exam mark loaded more highly on this function ($r = 0.94$ for second and; $r = 0.34$ for first function). Together, these two discriminant functions significantly differentiated the student categories, $\Lambda = 0.70$, $\chi^2(6) = 86.38$, $p<0.001$. The second function alone also significantly differentiated the categories of student, $\Lambda = 0.93$, $\chi^2(2) = 16.98$, $p<0.001$.

Figure 11 demonstrates how the first function separates the ex-Foundation Programme and DA-EFL students from the Augmented and DA-ESL groups. The second function distinguishes the two Access Programmes from the direct access EFL and ESL student groups; this difference is not as dramatic as the first.

Univariate tests confirm these findings. With a Bonferroni adjustment made to the criterion for significance (to $p = 0.01$), significant differences in practical and theory exam performances were found to exist across the groups, $F(3, 243) = 25.46$, $p < 0.001$, $\omega = 0.48$ and $F(3, 243) = 8.31$, $p < 0.001$, $\omega = 0.28$ respectively. Hochberg GT2 post hoc tests are given in Table 12.

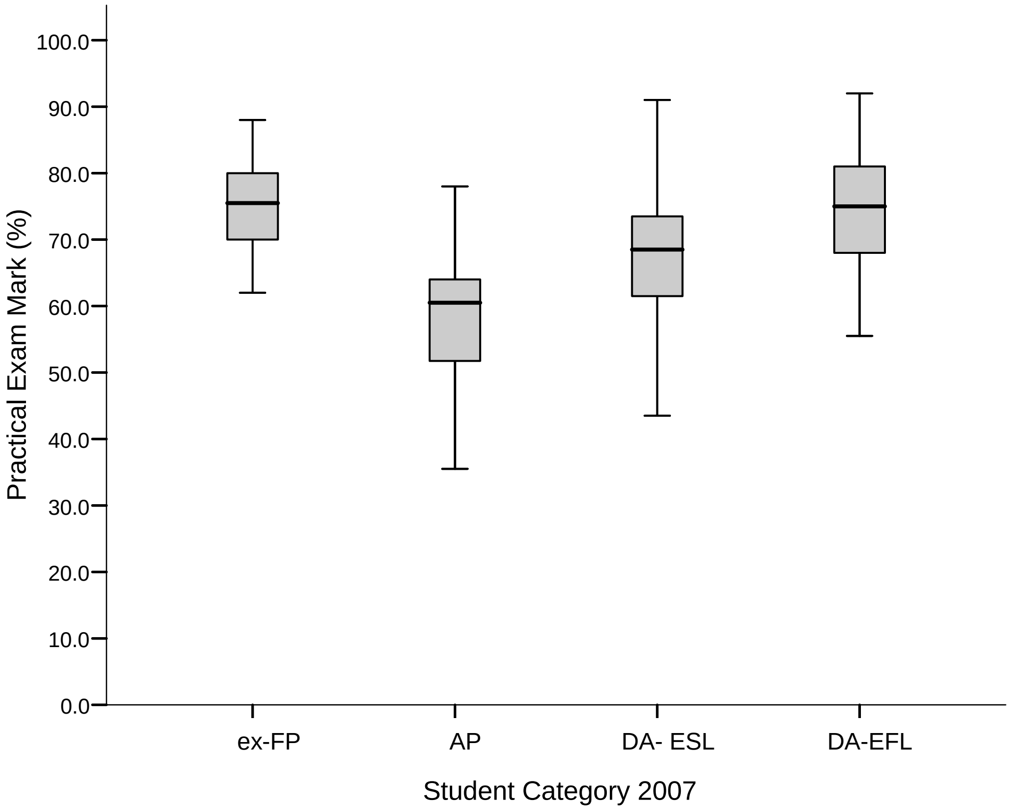

Figure 9. Distribution of practical exam marks in 2007 for ex-FP (*n* = 28), AP (*n* = 31), DA-ESL (*n* =117) and DA-EFL (*n* = 71) student groups.

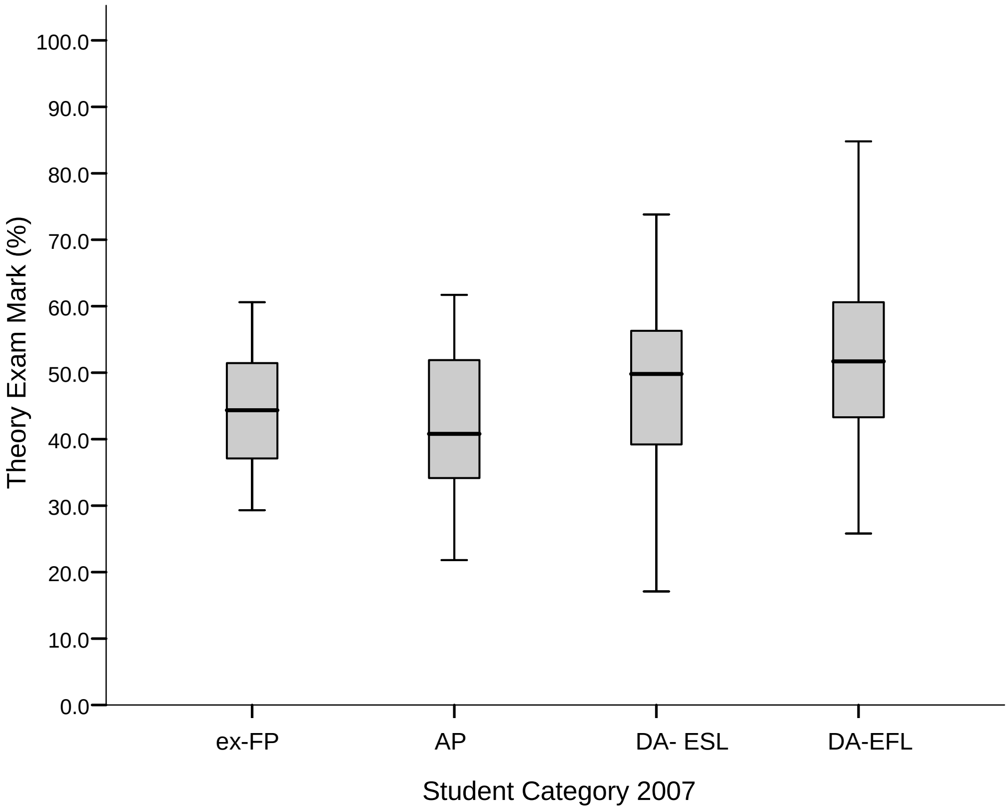

Figure 10. Distribution of theory exam marks in 2007 for ex-FP (*n* = 28), AP (*n* = 31), DA-ESL (*n* =117) and DA-EFL (*n* = 71) student groups.

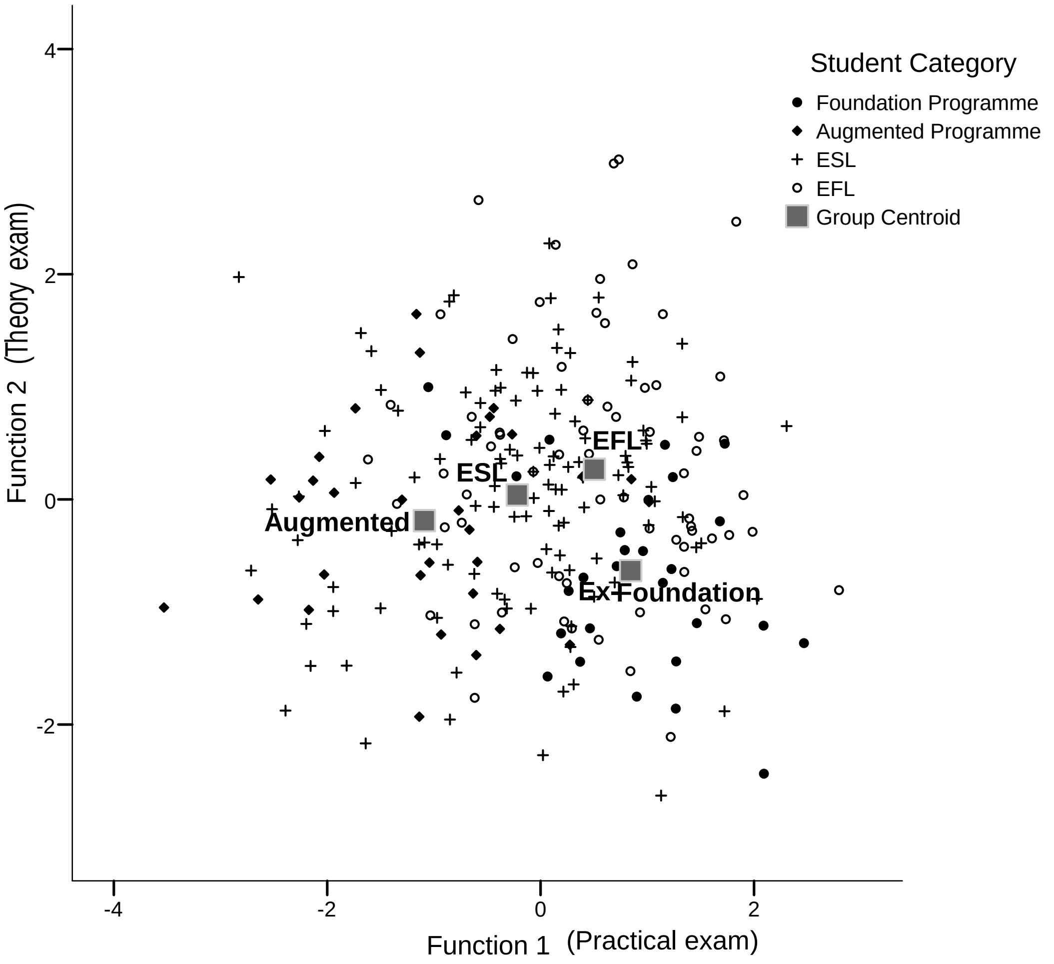

Figure 11. Discriminant function plot for the 2007 theory and practical exam results.

Table 12

Differences in Practical and Theory Exam Marks across Student Categories in 2007

		Practical Exam			Theory Exam		
Student Category		Sig.	*d*	Direction of difference	Sig.	*d*	Difference direction
ex-Foundation	Augmented	*<0.001****	1.9	ex-FP > AP	*0.923* N/S	0.3	ex-FP = AP
	DA-ESL	*<0.001****	0.9	ex-FP > DA-ESL	*0.744* N/S	0.3	ex-FP = DA-ESL
	DA-EFL	*0.998* N/S	0.1	ex-FP = DA-EFL	*0.007***	0.8	ex-FP < DA-EFL
Augmented	DA-ESL	*<0.001****	0.8	AP < DA-ESL	*0.069* N/S	0.5	AP < DA-ESL
	DA-EFL	*<0.001****	1.6	AP < DA-EFL	*<0.001****	1.0	AP = DA-EFL
DA-ESL	DA-EFL	*<0.001****	0.7	DA-ESL < DA-EFL	0.014*	0.4	DA-ESL < DA-EFL

Note. Marked differences are significant at $p < 0.05$. No outliers existed in the data; *d* refers to Cohen's *d*.

Student performance in 2008. Four outlying low (the minimum being 36%), and one high score (of 92%) in the practical exam marks were detected in DA-EFL student group. These scores were adjusted for subsequent analysis; no outliers were detected in the other student categories. Variance in these practical exam scores was considerably less in the ex-Foundation Programme group in comparison to the other three groups with half of the students here achieving more than 60% (Figure 12).

Three outliers were detected in the ex-Foundation Programme students' theory exam marks; two high (77% and 71%) and a low score of 32%. One exceptionally low score (of 12.5%) in the direct access ESL student group was also found. These outliers are not reflected in Figure 13 as such outliers were adjusted (as in all other such cases). As was the case in the practical exam marks, the ex-Foundation Programme students' marks in the theory exam exhibited less spread than the other groups (Figure 13). In addition, the lower quartile in this group was higher than those in the other three groups.

Initial heterogeneity of variance across student categories in the theory exam results necessitated a log transformation of the data. With both homogeneity of variances and equality of covariance matrices assumed, a MANOVA on the transformed data rendered a significant difference across groups in the theory and practical exam results tenable, Pillai's Trace V=0.32, $F(6, 486) = 15.19$, $p < 0.001$. Separate univariate ANOVAs on the transformed practical exam results revealed significant differences across the groups, $F(3, 240) = 33.17$, $p < 0.001$, $\omega = 0.53$. Untransformed data yielded identical results. With a Bonferroni correction applied to the level of significance (to $p = 0.025$), the univariate ANOVA on the transformed theory exam data however yielded no significant difference across the student categories, $F(3, 240) = 33.17$, $p = 0.032$, $\omega = 0.14$. Very similar results were achieved with the untransformed data. Hochberg's GT2 post hoc tests for pairwise comparisons support these findings (Table 13). Even though the results between the ex-Foundation and other categories of student are non significant for the practical exam results, the effect sizes are large. Similarly, medium sized effects are found in the non-significant differences between the direct access EFL students and both the Augmented and direct access ESL groups in the theory exam. These differences would account for the significant difference across the groups in the theory exam (if the significance level for this univariate ANOVA was retained at $p = 0.05$). It is clear that there is some question around whether these differences are really significant or not. The discriminant function plot admirably reflects the relationship between the groups in their performance in theory and practical exams (Figure 14), although, as is visible when comparing these results with those in Figure 12, the separation of the groups is not as marked as was the case in 2007.

The first function explained 99.6% of the variance (canonical $R^2 = 0.31$); the practical exam mark was loaded highly on this function ($r = 0.96$ for first and $r = 0.29$ for second function). The second function explained only 0.4% of the variance (canonical $R^2 = 0.001$). The theory exam mark was loaded highly on this function ($r = 0.96$, $r = 0.28$ for second and first functions respectively). Together, these discriminant functions significantly differentiated the student categories, $\Lambda = 0.69$, $\chi^2(6) = 90.21$, $p<0.001$. The second function alone did **not** significantly differentiate the student categories, $\Lambda = 0.99$, $\chi^2(2) = 0.42$, $p = 0.812$.

Table 13

Differences in Practical and Theory Exam Marks across Student Categories in 2008

Student Category		Practical Exam			Theory Exam		
		Sig.	*d*	Direction of difference	Sig.	*d*	Difference direction
ex-Foundation	Augmented	*0.140* N/S	0.8	ex-FP ≥ AP	*0.826* N/S	0.1	ex-FP = AP
	DA-ESL	*0.088* N/S	0.7	ex-FP ≥ DA-ESL	*0.914* N/S	0.1	ex-FP = DA-ESL
	DA-EFL	*0.154* N/S	0.8	ex-FP ≤ DA-EFL	*1.000* N/S	0.1	ex-FP = DA-EFL
Augmented	DA-ESL	*1.000* N/S	0.01	AP = DA-ESL	*0.999* N/S	0.1	AP = DA-ESL
	DA-EFL	<0.001***	1.5	AP < DA-EFL	0.085 N/S	0.4	AP ≤ DA-EFL
DA-ESL	DA-EFL	<0.001***	1.4	DA-ESL < DA-EFL	*0.067* N/S	0.4	DA-ESL ≤ DA-EFL

Note. Marked differences are significant at $p < 0.05$. *d* refers to Cohen's *d*. Results reflect analysis on log transformed data with outliers adjusted (5 and 4 for practical and theory exam results respectively).

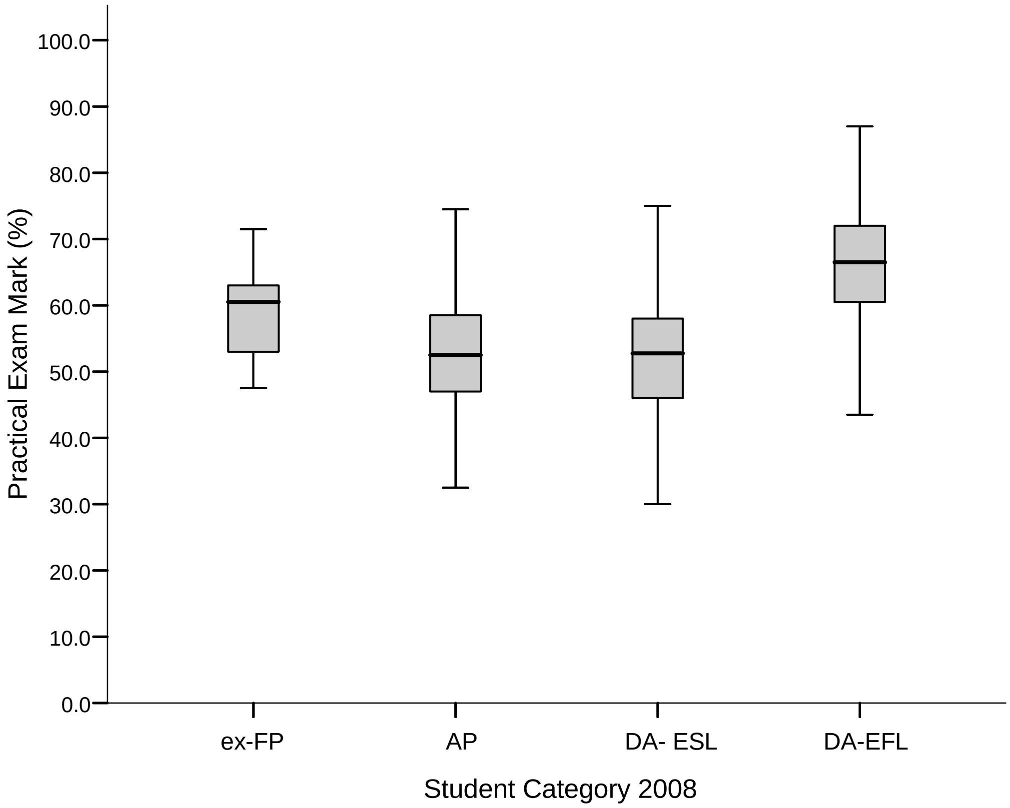

Figure 12. Distribution of practical exam marks in 2008 for ex-FP (n = 13), AP (n = 46), DA-ESL (n = 106) and DA-EFL (n = 79) student groups.

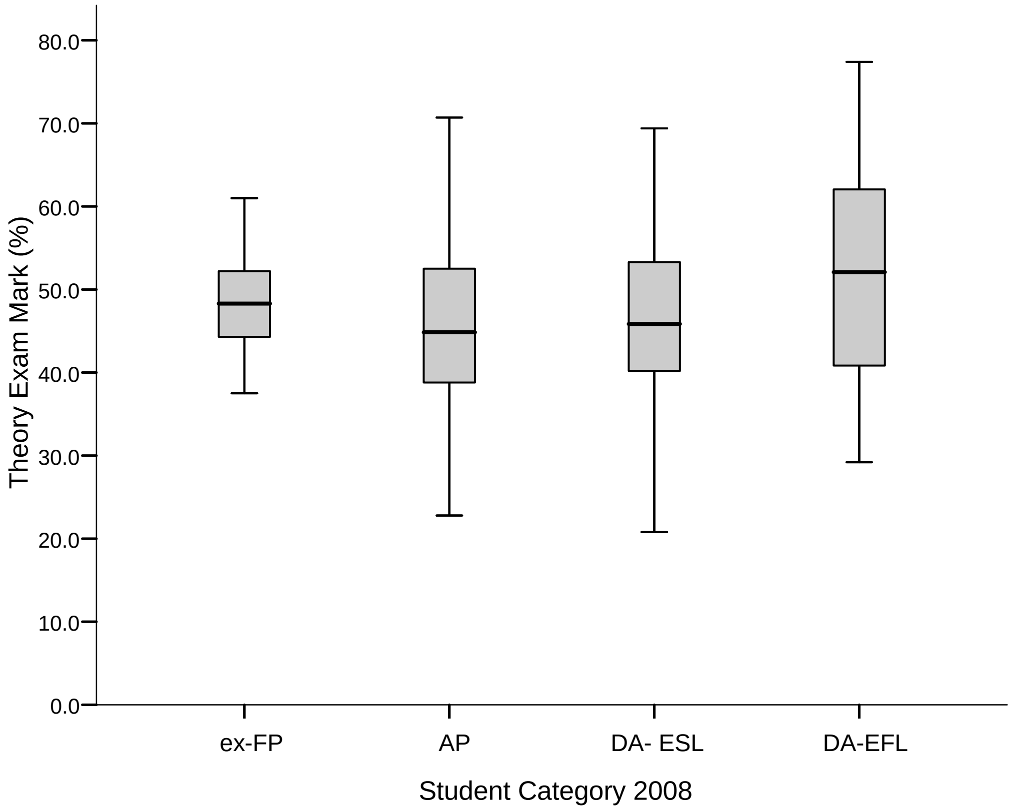

Figure 13. Distribution of theory exam marks in 2008 for ex-FP (n = 13), AP (n = 46), DA-ESL (n = 106) and DA-EFL (n = 79) student groups.

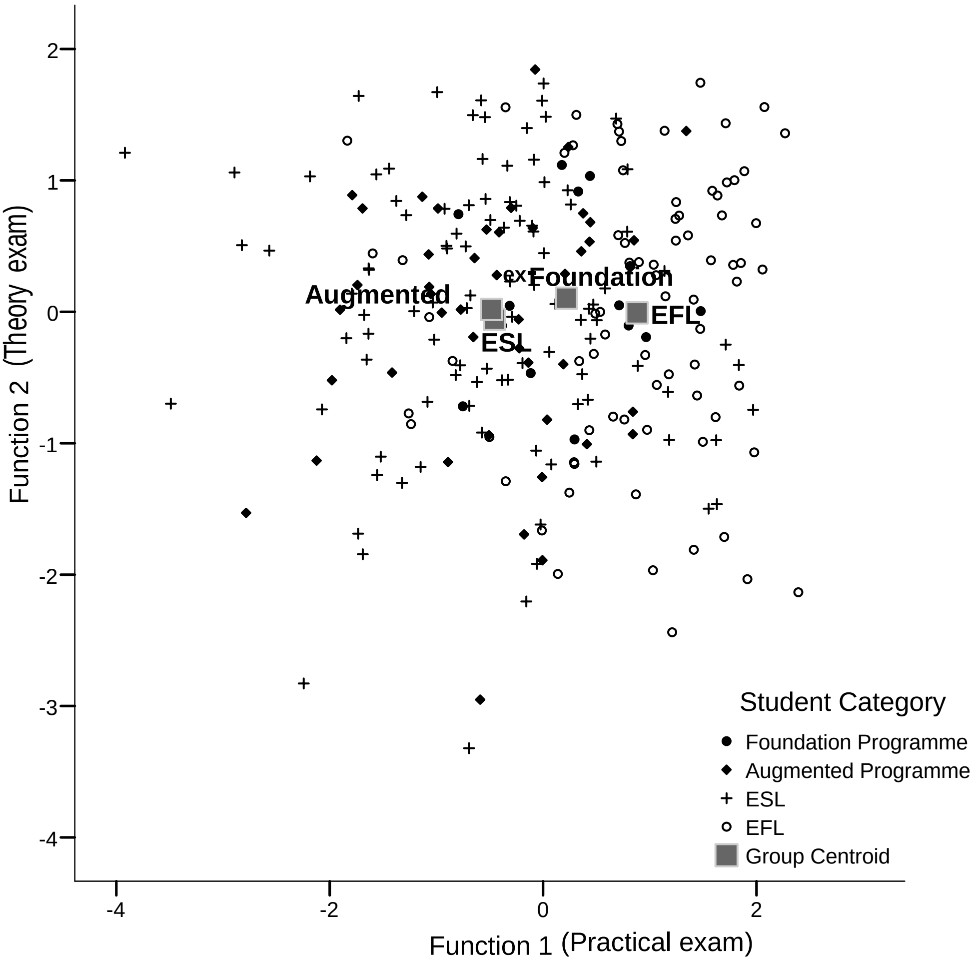

Figure 14. Discriminant function plot for the 2008 theory and practical exam results.

2009: A New Kind of Student – Very Similar Results

As already mentioned in Chapter 1, by the time data on the 2007 and 2008 mainstream performance had been analysed, data pertaining to how the 2008 cohort of Foundation students had performed relative to the first intake of NSC matriculants into mainstream in 2009, was available. Gaining an understanding of the influence of the National Senior Certificate relative to the Senior Certificate in terms of the preparedness of students for tertiary education was seen to feed significantly into issues of Science Access at UKZN.

Due to the different nature of the assessment strategy in 2009 relative to the previous two cohorts (see p.85), the CAM and theory exams were not analysed separately (in addition there was no practical exam). The final mark analysis was conducted to provide some indication of general trends in performance across the four categories of students.

Of the large intake of students in 2009 (406), 390 were included in analysis. Of these, 37% qualified to write a supplementary theory exam, this being a larger proportion of the cohort than is normally the case (e.g. 19% in 2007 and 31% in 2008). Student performance was thus analysed before and after this supplementary theory exam. In both cases a significant difference (albeit only medium sized) was found to exist in the final mark across the four categories of student; Welch $F(3, 78.724) = 12.14$, $p < 0.001$, $\omega = 0.3$ in the final pre-supplementary mark and $F(3, 386) = 12.82$, $p < 0.001$, $\omega = 0.3$ after the supplementary). In the former, variance across the student categories was not significantly homogenous, in the latter it was. Post hoc tests revealed how writing the supplementary exam benefitted the direct access ESL students in particular (of the five ex- Foundation Programme students who wrote the supplementary exam, three passed). Whilst all other pair-wise comparisons were similar across the student categories, the ex-Foundation Programme students performed significantly better than the direct access ESL group before the supplementary exams (Games-Howell, $p = 0.01$, $d = 0.6$) whilst after this exam, there was no significant difference between these two categories. Table 14 presents all pair-wise comparisons for final marks after the supplementary exam. Even though the differences between the ex-Foundation Programme group and the Augmented and direct access ESL groups were found to be non significant, the effect size is large.

Table 14

Differences in Final Mark in BIOL 101 across Student Categories in 2009

Student Category		Sig.	95% Confidence Interval		Cohen's *d*	Direction of difference
			Lower Boundary	Upper Boundary		
ex-Foundation	Augmented	*0.347* N/S	-1.98	10.78	0.6	ex-FP ≥ AP
	DA-ESL	*0.165* N/S	-0.95	9.96	0.6	ex-FP ≥DA-ESL
	DA-EFL	*0.956* N/S	-7.43	3.88	0.2	ex-FP = DA-EFL
Augmented	DA-ESL	*1.000* N/S	-3.98	4.18	0.1	AP = DA-ESL
	DA-EFL	*0.001***	-10.52	-1.84	0.7	AP < DA-EFL
DA-ESL	DA-EFL	*<0.001****	-9.09	-3.47	0.7	DA-ESL < DA-EFL

Note. Marked differences are significant at $p<0.05$. Analysis conducted after outliers were replaced. It must be noted that a significant difference was also found to exist between groups containing outliers for final marks score 2009, $F(3, 386) = 12.27$, $p < 0.001$, $\omega = 0.3$. Post hoc tests (in presence of homogeneity of variances) revealed group differences as above.

As was found in 2007, there was less variance in the ex-Foundation Programme student group than in the other three groups (Figure 15). In addition, the bottom 25% of students in the Augmented and direct access ESL groups were weaker than those in the Foundation or EFL groups (lower quartiles being 43% and 50% respectively).

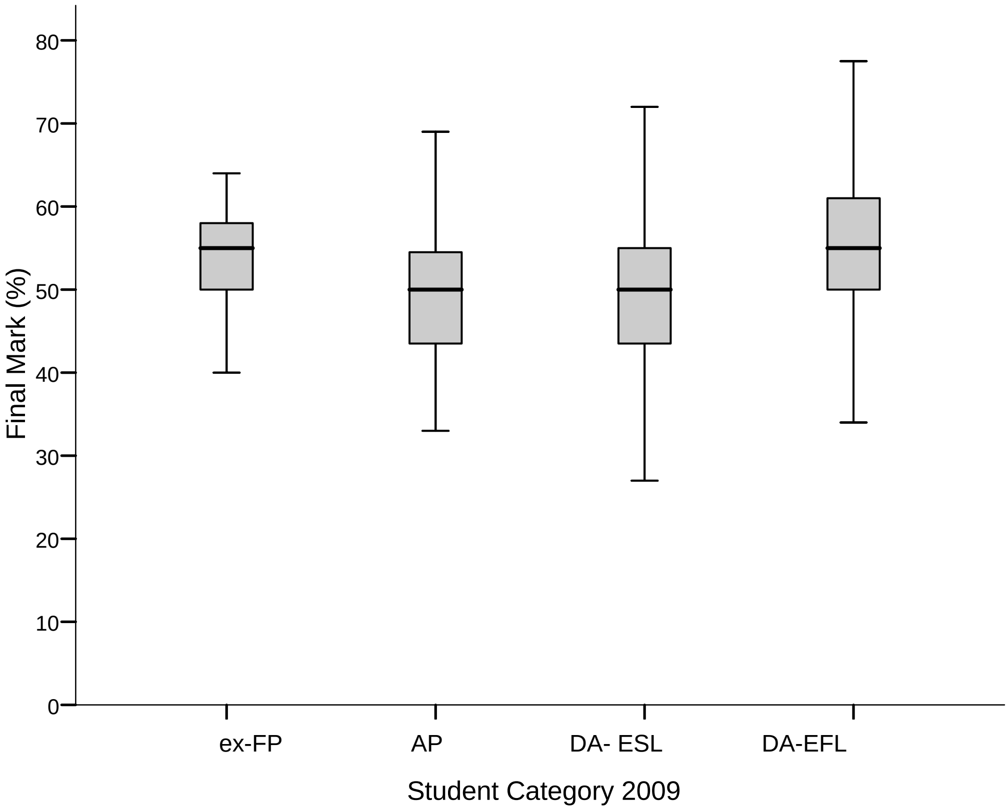

Figure 15. Distribution of final marks in 2009 for ex-FP (*n* = 21), AP (*n* = 43), DA-ESL (*n* = 208) and DA-EFL (*n* = 117) student groups.

Success of Science Access as Reflected by this Study

Clearly, as the results presented above indicate, the Foundation Programme on the Pietermaritzburg campus of UKZN has been successful in preparing those students who do pass their foundation year, for the challenges of an important first-year, mainstream module. In 2007, there were 28 students who progressed from the Foundation Programme into the first semester Biology module. Despite a very large difference in their matric entry qualifications, the Foundation students went on to outperform the Augmented students and there was no difference in the final mark score between the ex-Foundation students and the direct access English Second Language students. Furthermore, the ex-Foundation group exhibited a very small variability in the final mark score, suggesting that the programme was effective for the majority of students, and not only a select few.

In 2008, only 13 Foundation Programme students enrolled in the first-year Biology module. These students however did exceptionally well; their performance was particularly good in comparison to the DA-ESL group and statistically on a par with the DA-EFL students. The Augmented and DA-ESL students did not perform as well as the ex-Foundation Programme students relative to the DA-EFL students. This trend was repeated in 2009 with the intake of the first new school curriculum (the NSC) cohort directly into first year or into the Augmented Programme. Again, the ex-Foundation Programme students (of whom there were 22, all who had matriculated before 2008) outperformed the Augmented and the direct access ESL students. There was almost no difference in the performance of the ex-Foundation Programme and DA-EFL students. In addition, the supplementary exams boosted the pass rate of the direct access English Second Language students in particular, adding to the impression of vulnerability of this group. By comparison the ex-Foundation students are not as vulnerable as DA-ESL students suggesting a more solid framework with which to pursue their studies.

Disaggregating the final mark helped to elucidate which components of the final mark contributed most to the difference in performance of each student category. For the Continuous Assessment Mark (CAM), the trend is that the direct access students for whom English is a first language outperform the other three groups, but the Augmented students perform better than the ex-Foundation and direct access ESL groups. This is not surprising, given that the students in the Augmented stream receive individual attention and continuous support in the supplementary classes throughout the year to complete work that contributes to the CAM.

Whilst performance in the practical examinations may fluctuate, all categories of student routinely perform poorly in the theory exam. The Foundation Programme appears to prepare students particularly well for the practical component of the first-year module. The practical examinations are loaded heavily on the first function of the discriminant analysis and in both 2007 and 2008 the ex-Foundation Programme students, together with the direct access EFL students, are separated from the Augmented and the direct access ESL students on this basis. The second variate, which is heavily loaded on by the theory exam distinguishes the two access programmes from the direct access English First and Second Language student groups, the former being weaker in this regard. The ability of this variate to distinguish differences is not as dramatic as the first which is heavily determined by performance in the practical exam. It thus appears that, whilst there is poor performance across all the groups in the theory exam, it is the practical component that really distinguishes the groups from each other – and it is for this component that the Foundation Programme students are particularly well prepared. (However, given the changing nature of the assessment in this first-year module, and the decreasing importance placed on the practical component as indicated for example, by the elimination of the practical exam, ex-Foundation Programme students are unable to demonstrate their strengths to the same extent in 2009 and beyond).

Other Successes in Science Access

It is valuable to see this success in context of other access programmes. These findings are contrary to what Kloot, Case and Marshal (2008) have said about the performance in general, of Foundation Programme students in first year, namely that they struggle when entering the mainstream.

Furthermore, in the context of developing a grounded theory at the time the analyses described above were being carried out, it was appropriate to turn to other literature citing successes of selected access programmes as data to inform the direction that this study should take. Rollnick (2006) provides a synopsis of successes in Science Access internationally. In developed countries outside Southern Africa, secondary school level intervention initiatives appear to predominate. These target all students, only some of whom may continue in the sciences. They appear to have made little impact on increasing the numbers of target student graduates (minority groups in these instances), the emphasis, in the most part being more general access rather than access to science. For example, Zaaiman (1998) reports the surprising lack of resolution in the United States of America around issues of racial equality of access and performance. Rollnick (2006) reinforces this by citing Schuetze and Slowey (2002) as saying that most countries have not “embraced the principle of inclusive access” (p.615). Osborne (2003) does identify a move towards increasing (and widening) participation in higher education in Europe, in particular under the “banner of lifelong learning” (p.6), but acknowledges that there is room for improvement in equity and access to those who have historically not participated in (traditional) university education.

By comparison, in poorer (e.g. Southern African) countries it is considered more cost effective to direct access initiatives at tertiary level students who have already decided to pursue the sciences. The model most popularly used here is described by Rollnick (2006) as “in-reach, in house” (p. 618), based on the work of Osborne (2003). The Foundation Programme at UKZN is counted amongst these. In South Africa, by 2001, almost every university in the country had a foundation programme (of one form or another), offered as a post-school intervention for students from disadvantaged backgrounds (Pinto, 2001 cited by Rollnick, 2006). Of course, in South Africa, this pertains to the majority of the population rather than the ethnic minorities of concern as in the USA and Europe, for example

Rollnick (2006) concludes that the close monitoring of the success of these access programmes, the experience gained in their operation, and the wealth of research being done on them, places South Africa at the international forefront of work in the area of Access. Although there is a wealth of current research reported on Access initiatives in South Africa (e.g. Grayson, 2010, and see Rollnick, 2010 for comprehensive summary of programmes in South Africa), the following Access initiatives are worth considering in some detail.

UNIFY. A notably successful access programme is that which operates at the University of Limpopo (ex University of the North). Citing this programme, Rollnick (2006) has commented on the favourable impact that a high quality access programme, such as this, can have on a tertiary institution that is regarded as disadvantaged (see

Zaaiman (1998) for a description of "historically advantaged and disadvantaged institutions", p.11). Zaaiman (1998) recounts that a large proportion of students who passed the UNIFY access programme went on to enroll in science faculty based first-year courses at the university. These students consistently (over three reported years) far outperformed first-time and repeat mainstream students, a considerable achievement, considering that the ex-UNIFY student groups had very high proportions of students who did not qualify for normal university entrance. Zaaiman, van der Flier, & Thijs, (2000) point out that the fact that the UNIFY students did better than the repeating students indicates that the foundation year offers a better preparation for first-year study than doing first-year twice!

These trends continued in follow-up tracer studies (Mabila et al., 2006). Furthermore, progress through second year, and graduation from third year, found the proceed (and graduation) rate for the UNIFY students to be marginally above or equivalent to, that of the direct entry students (Mabila et al., 2006); this trend was observed for almost all the courses offered in the University of Limpopo Science Faculty. Zaaiman et al. (2000) attribute this success to effective, fair selection tests and strategies, and a close fit between selection and teaching.

In the earlier tracer studies (Zaaiman, 1998), the best predictors for performance in the first-year biology modules (and indeed for first-year chemistry, physics, maths and computer science modules) was final mark average achieved in the UNIFY programme, and not matric score, or mark achieved in the maths and science selection tests or English proficiency test. Zaaiman (1998) ascribes the positive student development during the UNIFY year to these results, suggesting that by the end of first year, the selection tests into the foundation year and matric scores were no longer relevant. These selection tests had been shown to have high predictive validity for access into UNIFY for these same students however, especially when used in conjunction with matric results (van der Flier, Thijs & Zaaiman, 2003; Zaaiman, 1998).

When considering the fairness of the selection tests, Zaaiman (1998) found that most of the students' parents had either no education (or only at a primary level). In many cases one parent was absent and occupation levels were restricted to unschooled manual work (or parents were unemployed or received a social grant). Students generally came from large families, and were for the most part first-generation students. English was a second language for all of the students studied over the three years. The majority of these students had attended schools classified as rural, and which were grossly under-resourced (see Zaaiman, 1998, pp. 110-114). These students were thus indeed considered disadvantaged; the profile of these students is shared by those of the UKZN Foundation Programme as already described.

Zaaiman (1998) also concluded that, within a foundation student body, there is the potential for some to be more disadvantaged than others. Although those indicated in Zaaiman's study as more privileged were found to have better English language proficiency than students from lower socio-economic and educational backgrounds, this was found to have no influence on bias against weaker (English) students. Given that the selection of these students was found to be both effective and fair, Zaaiman (1998) concluded that UNIFY was successful in meeting the University of the North's (Limpopo) and governmental goals towards addressing equity (DOE, 1997a).

The study by Zaaiman (1998) also found that as a consequence of low faculty entrance requirements, many students who had applied to UNIFY were directed to mainstream, where they fared poorly. Other students were directed into mainstream courses they didn't necessarily want to pursue because they didn't meet the entrance requirements for their first choice specialisations. Consequently Zaaiman, van der Flier and Thijs (2000) doubt the validity of the first-year selection criteria, saying these students would have benefitted greatly from the foundation programme they were denied access to. This practice was considered unfair to those **not** allowed entry to the access programme (Rollnick, 2006; Zaaiman, 1998). Given this, the ex-UNIFY students may be considered *advantaged amongst the disadvantaged.*

Nelson Mandela Metropolitan University Foundation Programme. Wood and Lithauer (2005) report that students passing through the foundation programme operating at the Nelson Mandela Metropolitan University (NMMU) do not only perform better in their degree studies than directly admitted mainstream students, but also benefit on a social and emotional level. This enables them to achieve in all spheres of university life, not only academically. They refer to this as "the added value" of a foundation programme (p. 1002). Although there were some negative perceptions of the programme such as a drop in levels of motivation (a consequence of repeating some of the foundation work in first year), and insufficient development of higher skills such as critical thinking, the research found that students placed a very high value on the intrapersonal and interpersonal growth they experienced.

Other successes in South Africa. As early as 1976, the University of the Witwatersrand (WITS) was operating some form of access programme. Successes in the nineties are reported by Rutherford and Donald (1993). Their study revealed that the pass rate of (the then) ex-Department of Education and Training (DET) students that had passed the foundation year was almost three times that of ex-DET students admitted directly to mainstream, despite their relatively much weaker school leaving results. Furthermore, they reported that these foundation programme students appeared “more motivated, more questioning and more interested in serious study” (p. 214) than the typical university first-year student. The College of Science, operating at WITS since 1991 has changed in form over the years to include an open supported learning component. Rollnick and Tresman (2004) argue that this programme has been the most successful access programme for Science in South Africa, producing nearly 400 graduates in six years. In 2007, the College of Science made way for a four-year extended curriculum, the college tutors were redeployed to mainstream and the successful teaching approach of the College integrated into the first-year mainstream courses. This has seen the pass rate of some mainstream courses consistently improve (Annual Report of the University of Witwatersrand, 2008).

Success through Selection; Success through a Remedial Curriculum

The South African Department of Education has acknowledged that the higher education sector should not “expect dramatic changes in the short term” (in the numbers of students qualifying for direct entry to mainstream, and the extent to which the NSC has prepared them for tertiary study) (Chisholm, 2010). In other words, the “disadvantaged student” is here to stay for some time. Only by identifying disadvantaged students with potential in science-based subjects, and giving them adequate support, can the Department of Education’s call for more South African scientists, engineers and technologists be met (Zaaiman, 1998; Zaaiman et al., 2000). As Zaaiman (1998) has said, the challenge for institutions with large numbers of first-generation students, is to select students using a fair procedure, and to adequately support them after admission; “meaningful academic and social-support mechanisms are crucial for these students to succeed” (p. 30).

As Zaaiman et al. (2000) have stated, the main aim of selection is to identify students who will succeed in a specific academic programme. But selection is very complex – both from a political and technical standpoint. Politically, higher education is required to promote the achievement of equity amongst the South African populace (DOE, 1997a; Herman, 1995; Chapter 1); here equity refers to both access and success of graduates. Governmental policies of transformation towards equity require not only fair, impartial, and unbiased assessment for selection to higher education, but also effectiveness (in producing competent graduates needed by South Africa) and efficiency (DOE, 1997a; van der Flier, Thijs & Zaaiman, 2003; Zaaiman, 1998). It has long been recognised that satisfying the objectives of equity and effectiveness in a fair manner, particularly in context of Southern Africa's past injustices, is not easy (Altink, 1991; Herman, 1995). The conflict that exists here is that granting access to students who show the most potential to succeed, may not necessarily increase access to disadvantaged students. Conversely selecting students who are more disadvantaged does not guarantee efficiency and high rates of success. Thus the challenge is to find a compromise that addresses both, one that enables access to the disadvantaged student and can ensure a measure of success.

In being selected into mainstream after successfully completing the Foundation Programme, **and** been successful in mainstream, the Foundation students at UKZN appear to have satisfied both of these conditions. *It would appear that they are now "the advantaged disadvantaged".*

Whilst it is tempting to cease considering the ex-Foundation Programme students vulnerable to failure, it would be prudent to support the academic remediation achieved in their Access year, by further exploring the factors that influence performance in first-year mainstream.

Indeed, there is much interest in the first year of tertiary education, as this is when students are most vulnerable (McInnis, 2001). As Pitkethly and Prosse (2001) point out, it is important for lecturers at tertiary institutions to have a deep understanding of factors that impact on the quality of learning to enable Faculty to enhance first-year student success and progression, and to address the worldwide concern of tertiary student attrition. These authors refer to evidence that generally, a high proportion of first-year dropouts occur because of psycho-sociological problems with adjustment or environmental factors rather than intellectual inadequacies. For example there may be a mismatch between the student and the university culture (Tinto, 1995 cited by Pitkethly & Prosser, 2002). Tinto (1998) relates that academic and social integration into the university environment, rather than isolation, particularly in the first year of university, is likely to ensure student persistence. Clearly this is one advantage that the ex-Foundation Programme students have over others in the mainstream cohort, having already been on campus for their foundation year.

McKenzie and Schweitzer (2001) however report conflicting results with respect to student integration, citing other academic and cognitive appraisal variables as having a greater effect on student performance.

In the study by Wood and Lithauer (2005) students felt that the NMMU Foundation Programme helped with the adjustments they needed to make in bridging the gap between school and the independence of university. They felt that the supportive and caring environment of the foundation programme helped them to adjust to affective factors such as homesickness, peer pressure, and loneliness which would, in an unsupported environment impact negatively on their studies. The study cites Moulder (1991) in describing this provision of coping skills as a growth model of ‘looking forwards and not backwards’ (p. 1008). Students also reported that the close interaction with staff in their foundation year, and the student-centred teaching approach, improved self-efficacy and gave them improved self-esteem, which helped to build their confidence. The authors claimed that the close association of staff and students helped in developing the emotional competencies which have been shown to be positively related to academic and social success. In this respect, Van der Zee, Thijs and Schakel (2002) have shown that ratings of emotional intelligence are better at predicting academic and social success than more traditional measures such as academic intelligence and personality (in particular autonomy for academic success and empathy for social success).

The close association between staff and students also played a role in inspiring an interest in, and enthusiasm and motivation for, a particular subject. In this regard, teachers who have “an enthusiasm for a subject”, “interest in learners’ experiences” and “enjoy teaching, make lessons stimulating, relevant and interesting, are fair … encourage questions … and never give up on learners” (Wood & Lithauer, 2005, p. 1014) are precisely those that are required in a student centred learning environment such as a foundation programme.

Wood and Lithauer (2005) report that the NMMU foundation programme students were “unanimous in their perceptions … of having developed self-knowledge, an improved sense of self worth, self management and communication skills and that their attitudes in general became more positive” (p. 1012). Self-knowledge is important in that it helps prevent students from registering for mainstream courses that they are not intrinsically interested in which, in turn might lead to lower motivation levels. Moreover the students had had the opportunity to build long-lasting support networks. The authors of this study claim that these factors are closely linked to optimal academic performance since students have been equipped with the requisite coping skills. Struthers, Perry and Menec (2000) (also cited by Wood & Lithauer, 2005) have shown that problem-focused, academic specific coping skills are more likely to result in better motivation levels and thus higher levels of academic performance than emotion-focused coping. These authors say that the explicit teaching of these coping skills (including study skills and time management) will serve students well in that they are effective in reducing academic stresses.

It is apparent that the NMMU foundation programme students were equipped with the life skills necessary to succeed in their studies as they progressed from their access year. Wood and Lithauer (2005) report that the effective teaching of these life skills improves academic learning which in turn, improves the classroom climate and produces learners who are inspired and interested in learning.

The ‘Added Value’ of the Foundation Programme in the CSA, UKZN

The findings of Wood and Lithauer (2005) resonate with experiences in the Foundation Programme of the CSA at UKZN. In the tradition of Glaser’s classical grounded theory where “all is data” (see Chapter 3), it is appropriate to turn to incidences in the Foundation Programme on the Pietermaritzburg campus that reflect findings very similar to those described above.

Barnsley and Liebenberg (2000b) emphasise the importance of a “whole person” approach to learning where students’ emotional and personal needs are met as well as those academic. They recognise that this requires a “conscious and explicit facilitation of students’ adjustment to the university and the learning of skills that will help them cope with the demands of life”. These authors report that students and staff of the Foundation

Programme develop strong working relationships with each other. When asked how this had affected them, the vast majority of the student cohort studied (2000) reported that the effect had been positive. Amongst other positive responses, students reported that they felt supported, had been able to develop a sense of "belonging", been encouraged to be responsible for their own learning, and that they had been assisted in their personal growth. Some specifically cited the benefit of these close relationships as helping to adapt to the university environment, increased motivation and interest (in a particular subject, and in learning in general), and others valued the help they received in dealing with personal problems. There were no reports of students feeling "marginalised" by the rest of the university community.

These findings were reiterated in a 2008 report on a student evaluation of the Foundation Programme, and the Life Skills component in particular (Barnsley, 2008b). Specifically this report refers to the heavy task of finding ways to best support students without places in university residence, financial support or those battling with hunger on a daily basis (26.5 % of the 2008 CSA student cohort on the Pietermaritzburg campus were found to be vulnerable to food insecurity). In spite of the very difficult situations many students found themselves in, students were for the most part positive about their experiences in the Foundation Programme, and felt that it had helped them adjust to university. Most of those taking part in the evaluation reported to "have a sense of purpose in life", "developed confidence", felt they were ready to "choose a career" as they had sufficient information about "themselves and about occupations", and importantly, felt they knew "what their strengths and weaknesses are". The problems with insufficient places for students in University residences not withstanding, not a single student was reported as feeling like an "outsider" to mainstream campus community.

Such student responses suggest that the counselling component of the Foundation Programme has successfully tapped in to the "particular resources that can be mobilised to their (students') advantage in higher education" (Marshall & Case, 2010, p. 493). In their attempt to reconceptualise the notion of disadvantage, these authors argue that by assisting students to develop their identities with a focus on personal growth, considerable support may be provided to them to achieve success at university. Generally however, institutes of higher learning do not make this extension beyond the formal curriculum.

Concerns around the Foundation Programme Model

Kloot, Case and Marshall (2008) have expressed concern around issues of “separateness” of the model of the original (UNP) Foundation Programme, for example the small student numbers and the feelings that these students had about being different or marginalized (although it must be noted in context of what has just been said above, Kloot and colleagues were drawing from a much earlier report by Inglis, Akhurst and Barnsley in 1994). To a large extent, these issues have fallen away along with the increase in size of the CSA student body, particularly following the merger with the University of Durban-Westville, and the expansion of the CSA to include augmented streams that very closely articulate with mainstream. Indeed, the current structure of the CSA has integrated academic development into mainstream to a large extent. Furthermore, judging from what has been said above in terms of the “added value” of the Foundation Programme it can be suggested that Foundation students do not actually *feel* marginalised and that their integration into the University has been facilitated by the programme.

In place of concerns around the marginalisation of Foundation Programme students are the challenges to employ a constructivist pedagogy such as that described in Chapter 4 within tight budgetary constraints and with increasing pressure to achieve pass rates that will ensure continued Government funding (DOE, 2006a). This has been felt by many Foundation Programme staff (personal experience, Annual module reports for the Foundation Programme, 2006-9). . In addition, staff are faced with an ever increasingly challenging student body as the consequences of the new Curriculum (NSC) are experienced (personal experience; see Blaine, 2009; Pauw, Dommisse & van der Merwe, 2012; Ramphele, 2009; Sapa, 2009; Taylor, 2009). Indeed, within these parameters, the threat of “the learning space” in academic development programmes taking on the basic skills model of the 1980s again is very real (see Kloot et al., 2008, p.812).

One issue around marginalisation that does prevail however is that the Foundation Programme students are not taught by mainstream academics and do not follow the mainstream curriculum. As such, in the eyes of Kloot et al. (2008), the intention of the Foundation Programme to expose students to the “content and patterns of speech perculiar to scientists” seems “abstract” (p. 808). Whilst not taking away from the merits of the Foundation Programme and the opportunities for innovation that have been taken advantage of in being separate and autonomous, these authors claim that, in reality, this amounts to marginalisation which results in (the programme) having limited impact on the mainstream which is where the change really needs to happen. In other words, they believe that what is really needed is a model of “infusion” (p. 809) where there is integration of (foundation) academic development principles into the mainstream of the university itself.

In fact Grayson (1997) acknowledged in the relatively early days of the UNP Foundation Programme that in order to address the needs of large numbers of disadvantaged students in the future (without compromising educational standards), the principles employed in the foundation teaching programmes would need to be integrated into mainstream courses. The University of Witwatersrand (Annual report of the University of the Witwatersrand, 2008) and the University of Cape Town (Kloot et al., 2008) are two major South African universities that have opted for an infusion-style, extended curriculum model, whilst employing foundation programme pedagogies and foundation staff, redeployed to mainstream.

Kloot et al. (2008) conclude that lessons learned “from foundation programmes may indeed be successfully integrated into the mainstream, not only at the University of Natal (now UKZN) but on a broader scale” (p. 809). There is no doubt from the results presented in this chapter that the foundation curriculum does much to prepare students for the challenges of the mainstream biology module. In light of this, Grayson’s vision for the future, and the current pressures experienced in the Foundation Programme (as discussed), there does indeed appear to be much potential in pursuing this notion of “infused academic development” within the context of mainstream biology modules at UKZN.

For now however, the Foundation Programme is a “holistic package” that has a distinctly different curriculum from mainstream – for better or worse. Given this, it is helpful in the context of continued support to ensure success as well as access (in striving for true equity as described above), to establish, relative to their advantage that they have gained by successfully completing the “package” of a foundation year, what other factors are affecting Foundation student performance in their first year. As Kloot et al. (2008) have said, “the reality is most (foundation) students often need further assistance” (after their foundation year) (p. 807). Grayson (1997) too has said that it is impossible to overcome a lifetime of disadvantage in one year. It is to this that Chapter 6 turns as the answer to the first question of the third research objective is sought.

CHAPTER 6

Attempt to Answer Question 1 of Objective 3: Factors Influencing Performance of Students in a First-Year Biology Module

Results and Grounded Theory Development

Question 1. Relative to those who are augmenting first year and those who have gained direct entry, what factors are affecting Foundation student performance in their first year?

Note: The grounded theory that emerges from the data analysis is written in italics after each section where results are presented.

Rationale for Research

Considerable research has been conducted internationally on the factors influencing academic performance and student attrition at university. McKenzie and Schweitzer (2001) outline the diversity of factors affecting academic performance, categorizing them as academic, psychosocial, cognitive (including self efficacy and attributional style) and demographic. No single study can profess to have investigated all these factors, and indeed an extensive range of literature citing various reasons for academic performance exists. Furthermore, it is apparent that generalisations about students' needs and experiences across university campuses cannot be made (Pitkethly & Prosser, 2001; Tinto, 1998). As Pitkethly and Prosse (2001) claim, each "university's situation is different, and will require action appropriate to its own situation" (p. 186). These authors add that "with specific knowledge of the experiences of its own students, the concerned university will seek to alleviate issues over which it has control". By identifying factors that influence academic performance, students who are at risk can be identified, interventions can be planned and support provided where necessary (Burton & Dowling, 2005). This is in line with the first of Tinto's (1987) six principles which underpin successful attempts to enhance first-year student academic performance; that is that "(s)tudents enter with, or have the opportunity to acquire, the skills needed for academic success" (cited by Pitkethly & Prosser, 2001, p.187).

In South Africa, the matriculation endorsement has traditionally been used as the baseline criterion for selection into degree programmes (Collier-Reed, Wolmarans & Smit, 2010; Griesel, 2001; Herman, 1995; Hunt et al., 2010; Mabila et al., 2006; Zaaiman, 1998). Different versions of the Swedish Points Rating System have also been commonly used, and English (or other language) and, where appropriate, maths performance used as indicators for future academic performance. In the points system, numerical values are assigned to symbols and grades achieved at secondary school level with complex weighting for different degrees (Foxcroft, 2006). This system of selection has been in flux for some time (see, for example, Griesel, 2003), and has been found in some institutions to be very unsatisfactory. Certainly research done in the nineties (e.g. Rutherford & Watson, 1990 and Zaaiman, 1998) suggested that for the most part, the Department of Education and Training (DET) Senior Certificate had little predictive value for future academic performance (an exception to this being the work of Haeck and colleagues e.g. 1997). At this time there was indeed, debate around whether the matric examination was a prognostic test to predict future academic success or an assessment of a standard of general education (Herman, 1995).

More recently, Van der Flier, Thijs and Zaaiman (2003) have recognised that there are conflicting reports on the predictive validity of South African matric results, particularly for low-scoring, educationally disadvantaged students. Stephen (2003) too, cites numerous research studies that point to weak statistical relationships between the matriculation results and tertiary performance of Black students whilst simultaneously being a good and consistent indicator for academic performance of White students. Indeed, reports on the matric results over the past decade abound (see reports in Reddy, 2006c), some being highly contentious (Jansen, 2003).

Foxcroft (2006) reiterates these findings, also citing reports that have indicated differences in the predictive value of matriculation marks for different ethnic groups, particularly during the apartheid years. She reports both gender and cultural biases in one study, showing that matric performance is a relatively good predictor for White (male and female) and Indian male students, but not so for Black students or Coloured and Indian female students. Furthermore, she questions the equivalence of matriculation marks from year to year, and alludes to the “upward creep” of matriculation results, stressing the need to equate Further Education and Training Certificate (FETC) scores/NSC from year to year if they are to continue to be used to admit students directly to university (Foxcroft, 2006).

Lourens and Smit (2003) in contrast, identified the matric score (Grade 12 aggregate) as playing the most important role in predicting a first-year student's success at Technikon Pretoria. To a lesser extent this study found that the levels of student social and academic integration, goal commitment and commitment to the institution affected student performance, as well as a mismatch between students and their field of study, financial difficulties and experiences of poor quality teaching and support. Nash (2006) found that while English language proficiency contributed to academic success, the matric score remained an even better predictor.

Certainly there has been much debate around the value of the NSC in preparing students for tertiary education (e.g. Collier-Reed, Wolmarans & Smit, 2010; Hunt et al., 2010; Jansen, 2011; Marshall, 2010; Wolmarans, Smit, Collier-Reed & Leather, 2010).

The selection criteria for entry into the Centre for Science Access and mainstream at the University of KwaZulu-Natal have been laid out already in some detail. What was established in the last chapter is that those students who have entered the mainstream by successfully completing the Foundation Programme fare well in first year in spite of their significantly lower entrance scores at the beginning of their access year. In gaining insight into the factors affecting these ex-Foundation Programme students relative to those that are augmenting first year and those that have gained direct entry, the challenges facing the ex-Foundation students in mainstream may be better understood. In addition, this insight may well provide opportunities for curriculum development, both at foundation level (so as to better prepare them for mainstream), and also at mainstream level so as to facilitate continuous support. The following analysis seeks to answer this question.

Methods for Data Collection

Permission to conduct research outlined in the current chapter, and gain access to the relevant data stored on the University electronic systems relating to students' school results, demographic information and university results was requested, and granted, from the relevant authorities (Appendices I-K). Excel files of the relevant data were forwarded to me from the Division of Management Information (DMI). Data was also accessed via the Examination of Results Schedules (ERS). The requisite data for the outcome variables for this part of research, namely students' continuous assessment marks (CAM), students' theory and practical exam marks, and final mark, **after** supplementary exams, in the 2007, 2008 and 2009 BIOL 101 modules, was accessed through the Student Management System (SMS) to which I was granted full access. Details pertaining to the explanatory variables are outlined below.

Ethical considerations were adhered to by ensuring that once data collation and cross-checking were complete, student numbers, and therefore all reference to personal information pertaining to a particular student, were erased from the data sets, ensuring anonymity (Appendix L).

Biographical data. By referring to records on the University of KwaZulu- Natal Student Management System (SMS), students were identified as being either ex-Foundation Programme (had completed the Foundation Programme in the year prior to enrolling in BIOL 101), Augmented Programme (enrolled in BIOL 195), English Second Language and English First Language direct-entry mainstream students (as already reported students identify themselves as having English as their first or second language on their registration forms, information which is captured on the University's management system (referred to as "student category"). Information pertaining to a student's gender, ethnicity, and home language was also captured from the SMS.

School history data. Data pertaining to each student's total Admission Points Score (APS) in the 2007 and 2008 mainstream cohorts had already been collected to meet the second research objective (Chapter 5). For the following analysis this composite APS total is referred to as "matric score" (Appendix A).

In the 2009 cohort some students had completed their schooling with a Senior Certificate prior to 2008 and some with the National Senior Certificate in 2008 when this was implemented. The matric scores (APS totals) for the 2009 mainstream Senior Certificate (SC) students were calculated using the criteria outlined in Appendix A. Similarly, the matric scores for the NSC students were calculated using the criteria outlined in Appendix B. Where, in the analysis of the 2009 data, NSC and Senior Certificate students are forcibly separated, the above matric scores are appropriate for each respective year of matriculation.

However, for the purposes of this research, where students in the 2009 mainstream cohort were not distinguished by year of matriculation, some adjustment of the scores of Senior Certificate students was required for parity across the student body. Admission point scores were normalised accordingly for the Senior Certificate students, and a "matric score equivalent" was calculated (in accordance with criteria outlined in Appendix B) by adding their converted subject scores using Appendix C (which provides details of the normalisation process used by Umalusi as described by Naidoo, 2010). For example, in the 2009 first-year student body, a 2007 Senior Certificate matriculant would receive seven admission points for achieving an A on HG. This student, had they been in first year in 2008 would have scored eight admission points for an A on HG. Similarly, for the 2009 mainstream data set, in comparison to a 2008 school leaver who achieved level 3 for a subject, a 2007 matriculant was awarded 3.5 if they had scored a SG C for this subject. In such instances of analysis, the term "matric score equivalent" was used.

For the combined 2007 and 2008 cohort data set, students' marks and symbols for English, Maths and Biology were also captured from the ERS. In addition, information pertaining to whether students had completed their subjects on higher or standard grade, and English as a first or second language was also recorded. Admission point scores for these individual school subjects were also recorded from the ERS.

For the 2009 data set, the levels achieved for English, Maths and Life Science for the NSC students were captured from the ERS, and converted to APS (Appendix B). For those students in this cohort who had Senior Certificates, APS for these school subjects were calculated using Appendix A. In a similar manner to that described above, an "APS equivalent" score was also calculated for these Senior Certificate students in the 2009 cohort.

Method for Data Analysis

Classification and regression tree analysis. "Research approaches that try to isolate the influences of a few variables for all students will simply miss the point and probably provide little in the way of useful, practical or policy relevant evidence" (Pascarella & Terenzini, 1998, p. 155). Heeding this concern, classification and regression trees (CRT) of Breiman, Friedman, Olshen, and Stone (1984) are an attractive non-parametric alternative to generalised linear modelling techniques conventionally used.

Trees may also be used as a descriptive and exploratory technique to support traditional regression models. The main difference between classification and regression trees is that the response variable described by the former is categorical, the latter refers to scale, continuous data (Breiman et al., 1984; De'ath & Fabricius, 2000; El-Emam, Goldenson, McCurley & Herbsleb, 2001). Explanatory variables can be nominal, ordinal or continuous for both classification and regression trees.

The computer package SPSS Base (version 15 for Windows) offers the Classification Trees ^{TM} procedure, with one of the available growing methods being CRT (SPSS Inc, ver. 15, 2006; SPSS Base 16.0 User's Guide, 2007). CRT is deemed the most useful and appropriate growing method for generating trees for the purpose of developing grounded theory primarily as it allows for surrogates to be employed (see SPSS Inc, 2004). Analysis for the research recorded in this chapter (and indeed later when exploring Foundation student performance in their Access year) was therefore conducted using this CRT option. The Classification Tree procedure can be used for "segmentation and stratification" (identifying cases that are likely to be members of a particular group, or assigning them into one of several categories respectively), "prediction" (to create a rule for the prediction of future events such as a student passing or failing, or achieving a particular mark), "data reduction and variable screening" (to select a useful subset of variables from a larger set to describe and explain an outcome/response variable) and "interaction identification" (identifying relationships that refer to only specific subgroups of, for example, students) (SPSS Inc, 2004, p. 2).

Not only does tree analysis avoid the complexities and restrictive assumptions of logistic and non binomial regression modelling, but they have particularly clear, visual appeal, and are easy to understand and interpret. Classification and regression trees are built by using a binary partitioning algorithm to recursively divide data into relatively homogenous, dichotomous groups, thus revealing the explanatory variables which best describe the response variable (Breiman et al., 1984). The analysis exposes a hierarchy of context dependent effects of the explanatory variables, which allows a clear picture of the interaction between factors influencing the response variable, to emerge. In the context of the grounded theory methodology strategy of this research, the codes emerged from the tree analysis to generate concepts, and help establish uniformity in the underlying data in a visible, accessible manner.

Trees are represented graphically with the root node (the entire, undivided data set) at the top, and the branches and leaves below (each of the terminal nodes, which are split no further may be referred to as leaves, the splits as branches). Each of the nodes in the resulting trees are characterised by a mean value (for a continuous response data) or by distribution (for categorical data), group size, and the values of the explanatory variables that define them. For categorical explanatory variables with only two levels, only one split is possible with each level of the variable defining one of the two resulting nodes. For categorical ordinal data with more than two (k) levels, there are $2^{k-1} - 1$ possible splits (De'ath & Fabricius, 2000). For continuous explanatory variables, a split is defined by values less than (and/or equal), and more than (and/or equal) to some value identified by the tree, there being u-1 possible splits where u refers to all possible unique values (De'ath & Fabricius, 2000).

With data being recursively partitioned (a "parent" into two "child" nodes) an attempt is made to maximise within-node homogeneity. Recursive splitting results in cases (students) being classified into smaller and smaller nodes, the similarity in the outcome variable within each node increasing at the same time. Similarly, the difference in the outcome variable **between** nodes also increases. The extent to which a node represents a heterogeneous subset of cases (in this research, students) is an indication of "impurity". This is measured by the least-squared deviation (LSD) measure of impurity for continuous outcome variables. A terminal node in which all cases have the same outcome value is regarded as being "pure". For nominal and ordinal outcomes (categorical data), a number of measures of impurity exist (SPSS Inc, 2004). The Gini impurity measure was selected for this analysis. Here, splits are based on squared probabilities of membership for each category of the outcome variable with a view to maximising homogeneity in each child node. A reduction in impurity can be calculated by comparing impurity of the root node with the sum of the impurities of the child nodes (Breiman et al., 1984).

For each split, each explanatory variable is evaluated to find the best cut point (continuous data) or groupings of category (nominal or ordinal outcomes). The explanatory variable that yields the largest reduction in impurity is chosen for the first split (Breiman et al., 1984). "Improvement", indicated on resulting trees, refers to the improvement in purity of child nodes resulting from a split of the parent node by the explanatory variable used to make the partition (the variable with the best improvement is selected for the split). It is possible to stipulate a minimum change in “improvement” when generating trees; the default of 0.0001 was retained for this analysis. The pruning criterion was however applied to avoid overfitting of the models (SPSS Inc, 2004). This means that after a tree is grown to its full depth (until the stopping criteria below are met), pruning trims it down to the smallest subtree that has an acceptable risk value. The default maximum acceptable difference in risk between the pruned tree and subtree of 1 (expressed in standard errors) was applied to this analysis.

CRT recursively splits nodes until one of a number of stopping rules is met (Breiman et al., 1984). Either the maximum tree depth specified is reached (for this analysis the default maximum depth of 5 was applied), or no further splits can be made as all terminal nodes meet one of the following conditions: the absence of a significant explanatory variable left to split the node, the number of cases in a terminal node is less than the minimum number of cases specified for a parent node or the number of cases in a child node would be less than the specified number of cases, were the node to be split (these minima for parent and child nodes were set at 60 and 10 respectively for this analysis).

The proportion of variance remaining unexplained by resulting regression trees is referred to as a risk estimate (SPSS Inc, 2004). This, removed from the within-node variance of the root node of tree, results in a value equivalent to R^2 in conventional regression. The risk estimate varies considerably with model complexity (e.g. different stopping criteria). Since tree analysis was employed for this research to describe and explain student performance in terms of a hierarchy of context dependent explanatory variables, rather than to gauge the proportion of total variation in the student body explained by the tree, risk estimates were not included in the analysis. Certainly, within the framework of exploratory, illustrative data interpretation such as was intended here, “risk estimates” are seen to have little additional value. However, in the current research, there was room to employ the equivalent misclassification rates of classification trees in certain circumstances where prediction is an objective (see Chapter 8).

CRT can use surrogates for explanatory variables where values for particular cases may be missing and where a high association with the original variable exists (Breiman et al., 1984; SPSS Inc, 2004). Surrogate splitters are explanatory variables that are not as good at splitting a group as the primary splitter but which yield similar splitting results; they mimic the splits produced by the primary splitter. Examination of surrogates and alternative splits can lead to a more complete understanding of competing explanatory variables and their relationships (De'ath & Fabricius, 2000). The association measure (the lambda coefficient for contingency tables, λ) indicates the degree to which splits based on the surrogate match those based on the actual predictor. The largest possible association value is 1.0 which means the surrogate mirrors the action of the primary splitter in the resulting tree and is a perfect substitute for it; these variables can be used interchangeably (El-Emam et al., 2001). For each variable when it appears as a surrogate, the improvements in purity, had that variable been selected for the primary split, are summed up for all nodes. These summed improvements are scaled relative to the best performing variable where the highest value is 100. Thus each explanatory variable's "importance scores" incorporate information both on the use of the variable as primary splitters, in addition to their relative worth as surrogates should the primary splitter be missing. The variables can therefore be ranked in terms of importance to the overall construction of the tree (Breiman et al. 1985; El-Emam et al., 2001; SPSS Inc, 2004).

Applying a model to other data files containing similar variables to generate the predicted outcome values for each case in that file is referred to as "scoring" (SPSS Inc, 2004, p. 99). In the form of SPSS command syntax, a generated model specifies the "rules" for assigning predicted values to cases in a data set.

CRT models are commonly used in a wide range of fields from medical diagnostics to ecological studies (see Morris and Fynn (2003) for a South African example), and even accident analysis and prevention (e.g. Elmitiny, Yan, Radwan, Russo, & Nashar, 2010). Hayden, Hayden and Gamst (2004) have used regression trees to identify predictors of success as Emergency Medicine residents from a set of variables available at the time applicants were screened. Although they are increasingly being used by educational researchers internationally (for an early example, see Grayson, 1997), classification and regression trees appear to have had limited exposure in South Africa. In one South African study by Lourens and Smit (2003), classification trees revealed that students studying in certain "subject matter categories" had a much better chance of being a successful first-year student (passing all requisite modules) than others, and success could be predicted on the basis of this category and grade 12 aggregate.

Key work informing the research presented here is that of Ma (2005). He claims to have “pioneered the application of CART (an alternative acronym for classification and regression tree analysis) in education research” (p.86). Indeed as Ma (2005) says, one of the most attractive features of this tool is its ability to “identify local interactions” that “holds great promises for informing education policy and practice” (p. 86).

Classification and regression tree analysis for BIOL 101. Classification and regression tree analysis (see above) was employed to analyse performance in the 2007, 2008 and 2009 BIOL 101 modules. Since those students in the BIOL 101 module in 2007 and 2008 had all completed the Senior Certificate, these two cohorts were combined into one data set (cohort being added as an explanatory variable). Of the 478 students, 234 completed the module in 2007, and 244 in 2008. For the 2009 cohort of 390 students completing the module, comprehensive data was available for 352 (excluding non-South African students). Of these, 133 had left school with a Senior Certificate and 219 (62%) had received a National Senior Certificate in 2008. Again, as in the analysis to meet the second research objective, only South African nationals were included in the analysis due to the availability of school history data. The explanatory variables included in the construction of trees are provided in Tables 15 and 16 below.

Previous analysis (reported in Chapter 5) had found differential performance across the four student categories (ex-Foundation Programme, Augmented Programme, or direct access English First and Second Language groups) in the final mark, CAM and theory and practical exams. Disaggregating the final mark had thus been helpful in elucidating where differences in performance existed. Similarly, it is prudent to assume that the factors contributing to performance in each of these student categories might differ across the components of the BIOL 101 module. Thus the average final mark, and the disaggregated CAM, theory and practical exam average marks were explored as outcome variables in the following analysis. In all instances, the outcome variable marks refer to the averages **after** supplementary exams had been written.

Table 15

Explanatory Variables included in the Construction of Classification and Regression Trees (CART) for 2007 and 2008 BIOL 101 modules

Variable	Explanation
gender	Male or female
ethnicity	Refer to results of analysis of BIOL 101 final mark below for explanation (Table 17)
cohort	Either 2007 or 2008 mainstream cohort
home language	Students were recorded as speaking either Zulu, Xhosa, Sotho, "other African language", or English as a home language
student category	Students were classified as ex-Foundation Programme, Augmented Programme, or direct access English Second or First Language (ESL and EFL respectively)
matric score	Refers to the sum of the admission points scored for all SC subjects as described above
English as first or second language	Refers to whether students wrote SC English as a first or second language
English mark* Notes 1and 2	Percentage achieved for school English
English APS* Notes 1and 2	Admission points scored for English as outlined above (Appendix A)
Maths grade	Students had completed school maths on either Higher Grade or Standard Grade
Maths APS* Note 3	Admission points scored for maths as outlined above (Appendix A)
Biology studied at school	A small proportion (5% and 7%) of 2007/08 students respectively had not studied biology at school
Biology grade	Students had studied school biology on either Higher Grade or Standard Grade
Biology APS* Note 3	Admission points scored for biology as outlined above (Appendix A)
Supp. exam	Students had either been granted (and written) a supplementary exam, or not
Module repeated	Either students were registered for the module for the first time, or had repeated the module once (or even twice)

Notes.

1. All 2007/08 students had completed school English on Higher Grade.
2. Although a good correlation was found to exist between English APS and English mark (%) ($r = 0.96$, $p < 0.001$), the two variables were not always revealed as good surrogates for one another, and it was decided to retain English mark as a separate explanatory variable. English APS used in preference for English symbol (perfect surrogate, $r = 1.00$, $p < 0.001$).
3. Different grades rendered comparison of marks and symbols achieved meaningless. APS for each school subject used in place of these scores.

Table 16

Explanatory Variables included in the Construction of Classification and Regression Trees (CART) for 2009 BIOL 101 module

Variable	Explanation
gender	Male or female
ethnicity	Refer to results of analysis of BIOL 101 final mark below for explanation (Table 17)
home language	Students were recorded as speaking either Zulu, Xhosa, Sotho, “other African language”, or English as a home language
student category	Students were classified as ex-Foundation Programme, Augmented Programme, or direct access English Second or First Language (ESL and EFL respectively)
matric year	Students matriculated with a either a SC prior to 2008 or a NSC in 2008
matric score	Refers to sum of admission points scored for all SC/NSC subjects as described above
matric score “equivalent” Note 1	Subject scores of students writing the SC were recalculated using Appendix C to make them comparable to the NSC; the sum of these admission point scores for each student is referred to as “matric score equivalent”
English as first or second language	Refers to whether students wrote SC/NSC English as a first or second language
English APS* Note 1, 2,3	Admission points scored for school English in the SC or NSC
English APS equivalent* Note 1, 2,3	Admission points scored for school English of students writing the SC were converted using Appendix C to make them comparable to the NSC (see Note 1)
Maths APS* Note 1, 2	Admission points scored for school maths in the SC or NSC
Maths APS equivalent* Note 1, 2	Admission points scored for school maths of students writing the SC were converted using Appendix C to make them comparable to the NSC (see Note 1)
Biology studied at school* Note 4	A small proportion (7.7%) of students had not studied biology/life sciences at school
Biology APS* Note 1, 2, 4	Admission points scored for school biology in the SC or NSC
Bio APS equivalent* Note 1, 2, 4	Admission points scored for school biology of students writing the SC were converted using Appendix C to make them comparable to the NSC (see Note 1)
Supp. exam	Students had either been granted (and written) a supplementary exam, or not
Module repeated	Either students were registered for the module for the first time, or had repeated the module once (or even twice)

Notes.

1. Where "matric year" was forced as a primary splitter of the root node, "matric score" and APS for each subject refers to scores applicable to each year; scores earned in SC before 2008, NSC from 2008 onwards. Alternatively, where "matric year" was not forced as a primary splitter of the root node, "matric score equivalent" and "APS equivalent" for each subject is referred to. For NSC students, scores and "score equivalents" are one and the same, but the latter term is used when analysis requiring "score equivalent" for SC students was conducted. "Scores" and "score equivalent" variables were never used simultaneously in tree construction.
2. There was no grade distinction in 2008 for NSC subjects written.
3. All those students writing the SC had written English on Higher Grade.
4. The NSC equivalent of biology is referred to as life sciences.

Results of Data Analysis

Note: The grounded theory that emerges from the data analysis is written in italics after each section where results are presented.

BIOL 101 Final Mark, 2007 and 2008. Whilst establishing the data set to be used in the previous analysis (Chapter 5, relative performance of the four categories of student), it was noticed that routinely, Indian students, while performing well in matric, often did not fare so well in the BIOL 101 module. Indeed, Hochberg's GT2 post hoc tests revealed large differences in the final marks between the Indian and White students (the majority of the direct acess English First Language student group) in spite of no such difference in matric score (Table 17). These pair-wise comparisons were in context of significant differences across ethnic group in both matric score and final mark, $F(3, 474) = 42.22$, $p < 0.000$, $\omega = 0.5$ and $F(3, 474) = 32.11$, $p < 0.000$, $\omega = 0.4$ respectively. For this analysis, 2007 and 2008 cohorts were considered together and homogeneity of variance across the ethnic groups was found to exist in the matric score, $F(3, 474) = 1.54$, *ns*, and final mark $F(3, 474) = 0.59$, *ns*.

Table 17

Differences in Matric Score and Final Marks across Ethnic Groups

		Matric Score		Final Mark	
Ethnic Group		Sig.	Cohen's *d*	Sig.	Cohen's *d*
Black African	Coloured	*0.602* N/S	0.5	*0.997* N/S	0.2
	Indian	*<0.001****	0.9	*0.189* N/S	0.3
	White	*<0.001****	0.9	*<0.001****	1.1
Coloured	Indian	*0.858* N/S	0.4	*0.683* N/S	0.5
	White	*0.183* N/S	0.7	*<0.001****	1.2
Indian	White	*0.241* N/S	0.2	*<0.001****	0.8

Note. Ethnic Groups were Black African ($n = 329$), Coloured ($n = 9$), Indian ($n = 50$) and White ($n = 90$). Marked differences are significant at $p < 0.05$. Analysis conducted after outliers were replaced. It must be noted that a significant difference was also found to exist between groups containing outliers for matric score and final marks, $F(3, 474) = 41.05$, $p < 0.000$, $\omega = 0.5$ and $F(3, 474) = 31.96$, $p < 0.000$, $\omega = 0.4$ respectively. Post hoc tests revealed group differences as above.

These differences, internal to the direct access English First Language student group in particular, thus required addition of ethnicity as a variable into the regression tree analysis. In addition, given the significant differences in final marks that were found to exist across the two years (2007 and 2008), “cohort” was also included in the construction of the initial regression tree (Figure 16) for analytical purposes. These are but two examples of how emergent properties of the data can dictate theoretical sampling when employing grounded theory methodology (see page 54, Chapter 3).

When attempting to illuminate factors affecting student performance that are open to remediation, it is unhelpful to include influences such as ethnicity and cohort, and consequently both of these variables were then excluded in the construction of a second regression tree (Figure 17). The influence of the supplementary exam process was also initially included in the generation of these two trees, but was removed once it became obvious that this variable was an unhelpful primary splitter in understanding performance (naturally those students who had written supplementary exams were similarly weak by virtue of having had to write these exams, and would be grouped by the tree-building process). This variable was thus deemed superfluous, and excluded from subsequent analysis.

These initial trees were constructed using all 478 students, 29 of whom had not studied Biology at school and consequently performance in this school subject could not be included (only whether it had been studied or not). A further two trees were then constructed for this subset of 449 students to examine the influence of school Biology on their performance in the first-year Biology module. As explained above, for analytical purposes, “cohort” and “ethnic group” were first included in the construction of trees, and then excluded, to highlight factors open to remediation.

Figure 16 clearly reflects the general difference in performance across the ethnic groups. Resonating with Foxcroft’s (2006) findings, for the White students, it was their matric score that best distinguished the better achievers from others in this ethnic group; for both the 2007 and 2008 cohorts of Black African, Coloured and Indian students, it was their school English mark. It appears that in order to have had a fair chance of passing the first-year Biology module, these students needed to have achieved around 65% for English at school. This English subject may have been taken as either a first or second language, as this variable did not appear in the tree (only as a surrogate). Given these results, it is not surprising that "home language" was shown to be the most viable surrogate for "ethnic group" (improvement in purity = 11.79, λ coefficient for contingency tables = 0.28). The Admission Points Score for school maths (Maths APS) was found to be a possible alternative splitter for only White students (Node 1) (improvement in purity = 2.87 versus 4.75 for matric score).

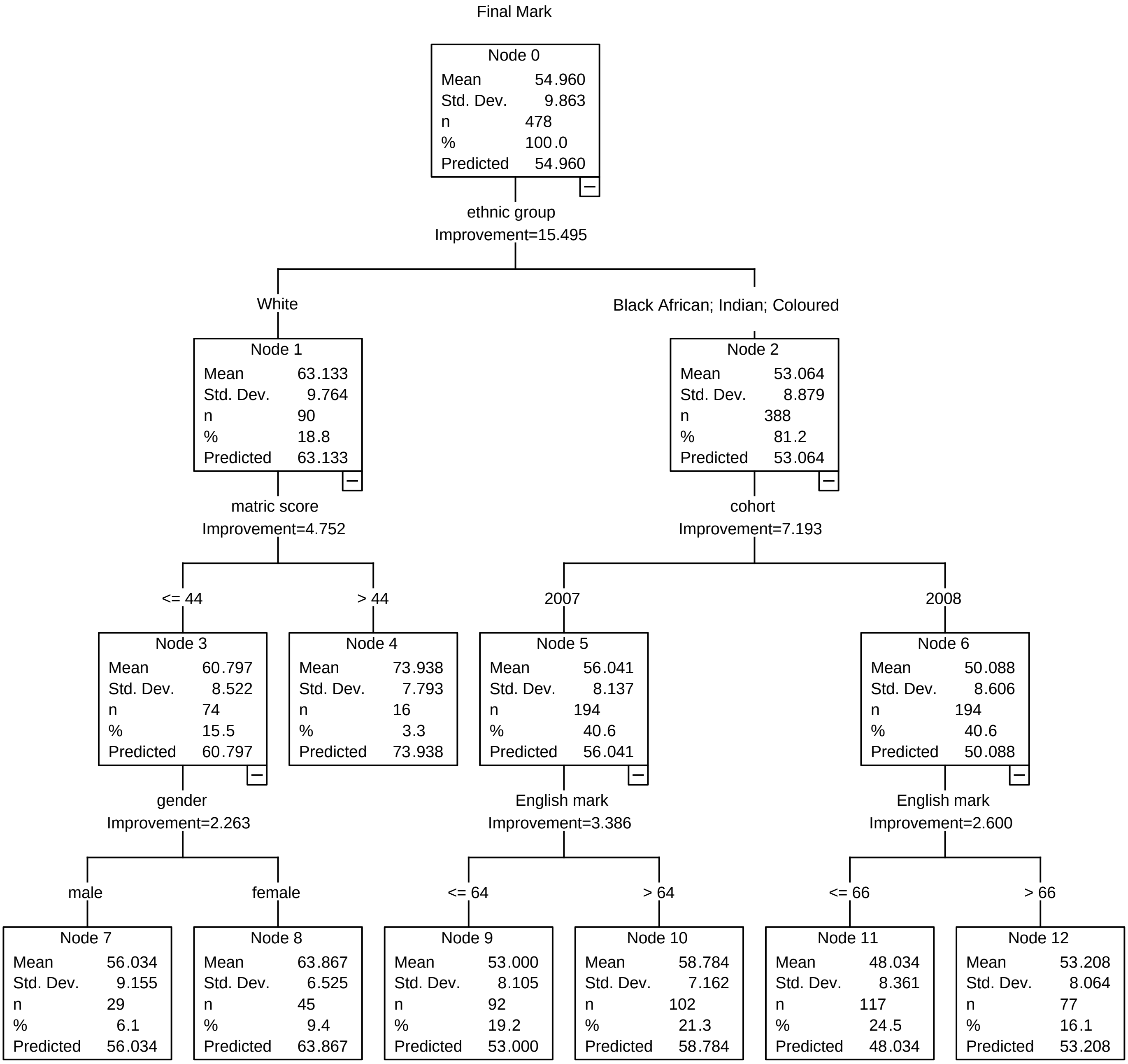

Figure 16. Regression tree for 2007 and 2008 final marks for BIOL 101 (*N* = 478). Students who did not study Biology at school were included. Cohort and ethnicity were included in construction of the tree.

The tree generated with those students who had all studied school Biology (*N* = 449) (with ethnicity and cohort included in tree generation) mirrored Figure 16 with the only exception being that Biology APS superceded matric score (and Maths APS) as the primary splitter of node 1 (improvement in purity = 3.93, λ coefficient for contingency tables = 0.49). School Biology performance was a good indicator of future performance in Biology for only the White students; performance in school English was more important for those students who are Black African, Indian or Coloured. In fact, whether students in nodes 5 and 6 (Figure 16) had studied Biology at school or not, and how they had performed in school maths had almost no bearing at all on their performance in the Biology module (node 5 improvement values of 0.02 and 0.06 for Biology studied or not, and Maths APS respectively; node 6 improvement values of 0.04 and 0.71 respectively). Similarly in the subset of those students who had all studied school Biology, performance in Biology for the Black African, Indian and Coloured students (node 2) was not as important as their performance in school English in both 2007 and 2008 (Biology APS improvement in purity = 2.77 and 1.37 for nodes 5 and 6 respectively.)

To gain insight into general trends across all ethnicities and across the two years studied, "ethnic group" and "cohort" were then excluded from tree construction. With these two influences removed, performance in school English became the primary splitter of the root node (Figure 17) (and attained the relative importance score of 100% in terms of overall tree construction). Relative to the within-node variance of the root (97.07), the impurity change represented by school English mark (15.35) represents almost 16% reduction in within-node variance. Those students who fell into the first daughter node (those achieving 64% or less for school English) had an average of 50.44% (*SD* = 8.65), whilst those achieving higher English marks performed significantly better in BIOL 101 (*M* = 58.36, *SD* = 9.35), $t(476) = 9.46$, $p < 0.001$; a fairly large effect size of $r = 0.4$ (two-tailed). Somewhat smaller reductions in impurity are achieved in the first node by splitting the DA-EFL and ex-Foundation Programme students from the Augmented Programme and DA-ESL (improvement = 1.52). Most of the ex-Foundation students were to be found in node 4; the remaining 8 are included in node 9. In splitting node 3 (the Augmented Programme students and a group of direct access students for whom English is a second language), the English mark comes into play yet again. Those students in this node may well have benefited by having completed the Foundation year before registering for mainstream.

Matric score was comparatively more effective at differentiating those students that performed best in the module (node 6, *M* = 69.87, *SD* = 10.31) from those whose performance was above average (terminal nodes 9 and 10). Table 18 provides a description of each of the terminal nodes of this tree, ordered (left to right) according to performance in final BIOL 101 mark.

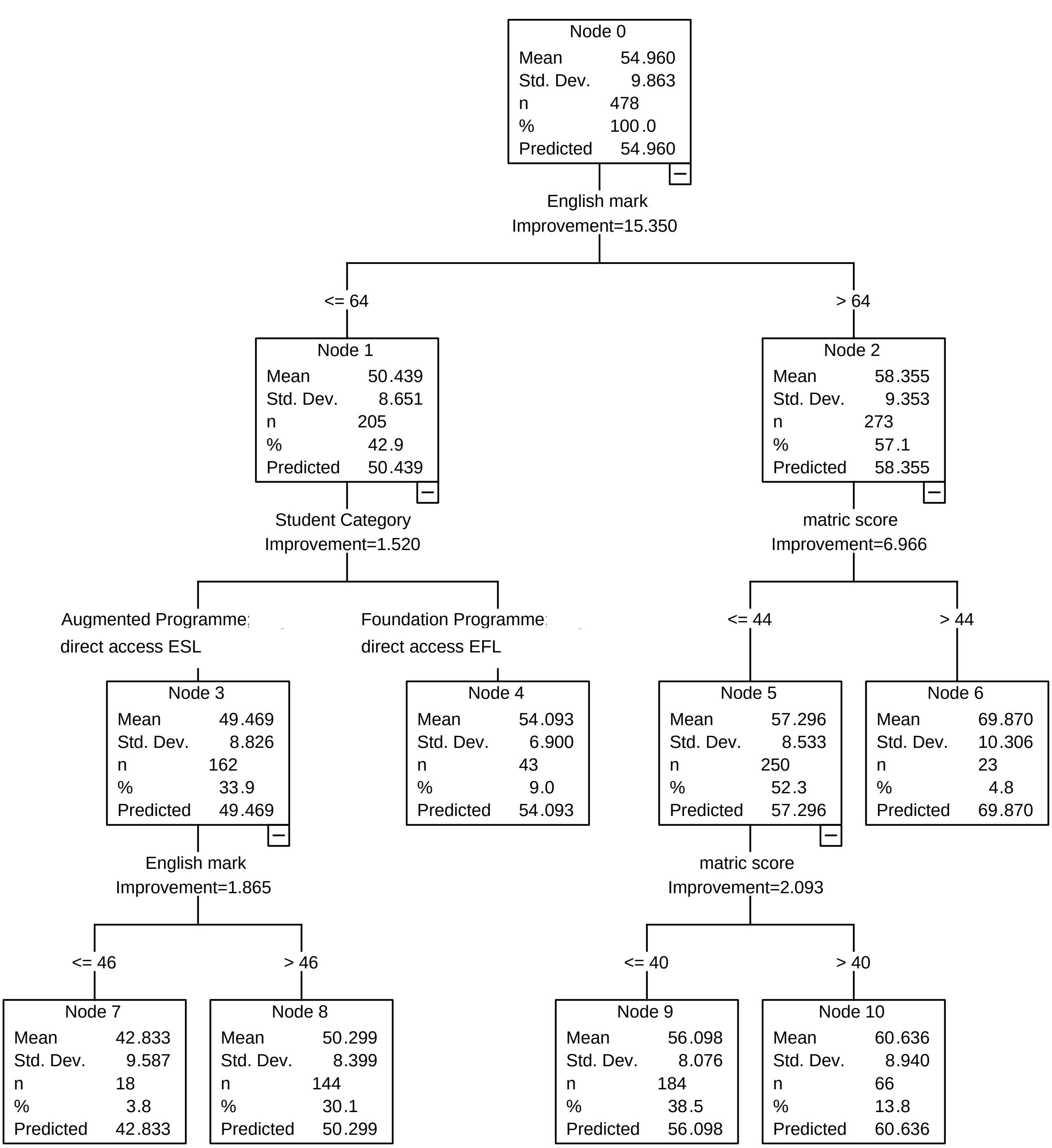

Figure 17. Regression tree for 2007 and 2008 final marks for BIOL 101 (*N* = 478). Students who did not study Biology at school were included. Cohort and ethnicity were **excluded** in construction of the tree.

Table 18

Description of Student Groups in Terminal Nodes of Tree in Figure 17 where Cohort and Ethnic Group have been Excluded as Explanatory Variables

	Student Group						
Variable	0 (478)	1(23)	2 (66)	3 (184)	4 (43)	5 (144)	6 (18)
Node in tree		***6***	***10***	***9***	***4***	***8***	***7***
Average final mark (29%-87%)	**54.96**	**69.9**	**60.64**	**56.10**	**54.10**	**50.30**	**42.83**
Proportion females in group	0.54	0.87	0.73	0.64	0.79	0.40	0.22
Proportion of 2008 cohort in group	0.51	0.70	0.59	0.42	0.37	0.60	0.50
Proportion Black Africans in group	0.69	0.09	0.32	0.60	0.77	1.00	1.00
Proportion Coloureds in group	0.02	0.04	0.02	0.04	0	0	0
Proportion Indians in group	0.10	0.17	0.22	0.15	0.07	0	0
Proportion Whites in group	0.19	0.70	0.44	0.21	0.16	0	0
Proportion of ex-Foundation Programme students in group	0.09	0	0	0.04	0.77	0	0
Proportion of Augmented Programme students in group	0.15	0	0	0.08	0	0.34	0.5
Proportion of direct access ESL students in group	0.45	0.13	0.32	0.48	0	0.66	0.5
Proportion of direct access EFL students in group	0.31	0.87	0.68	0.40	0.23	0	0
Proportion of students who wrote SC/NSC English as a first language	0.47	0.96	0.86	0.58	0.30	0.18	0
Proportion of students who did SC/NSC Biology	0.94	0.96	0.93	0.93	0.98	0.94	1.00
Average English mark (37%-91%)	65.05	79.09	75.41	71.04	56.12	55.88	42.67
Average matric score (21-50)	36.43	46.83	42.12	36.09	30.14	34.80	33.83

Note.

Explanatory variables not revealed in the trees of Figures 16 and 17 have not been included in this descriptive analysis (with the exception of whether students did English at school as first or second language, and whether they did SC/NSC biology/life sciences or not.

Even in the subset of students who had all studied school Biology, English language proficiency was found to be more important than other factors in determining performance in the first-year module (Figure 18). Again, on average, those who achieved less than 64% in this subset of students, did significantly poorer than those who scored above this mark in English at school (node 1 $M = 50.69$, $SD = 8.61$; node 2 $M = 58.59$, $SD = 9.34$), $t(447) = 9.20$, $p < 0.001$, $r = 0.4$ (two-tailed). As was the case with the whole set of students (Figure 17), the English mark reduced impurity in the root node by 16%. The variables that best acted as surrogates for this factor were whether students had done English at school as a first or second language (improvement in purity = 12.89) and home language (improvement in purity = 12.08), neither of which were particularly good substitutes (λ coefficient for contingency tables = 0.398 and 0.357 respectively). Biology APS only featured as a primary splitter amongst those students who achieved more than 64% in school English (Figure 18, nodes 5 and 6). Here, generally those students who achieved more than a Higher Grade C (SG A being the equivalent in terms of APS scores) in Biology performed better than those who got less for this subject at school. For those students who were not as proficient in school Biology and had not repeated the module, those who had passed through the Access Programmes performed, on average, better than those who had not (Figure 18, terminal node 11).

Only in the second node (Figure 18) was matric score indicated as a possible surrogate for Biology APS (improvement in purity = 7.408 versus 8.318 for the latter); this confirmed trends in earlier trees. Nowhere was the performance in school maths considered as a viable surrogate.

English language proficiency has had particular influence on the performance of those students who are "disadvantaged" by having lower levels of proficiency in English when they arrive at University. Only above a certain level of English proficiency (as indicated by school performance in English) will students be advantaged in mainstream by having achieved well at school (generally, and in school Biology). Those students not "advantaged" by higher levels of English language proficiency are advantaged by having done the Foundation Programme in their Access year. Others, who have in the past been admitted directly to mainstream on the basis of their performance in the Senior Certificate, but who had lower levels of English proficiency may well have benefited by accessing mainstream via the Foundation stream.

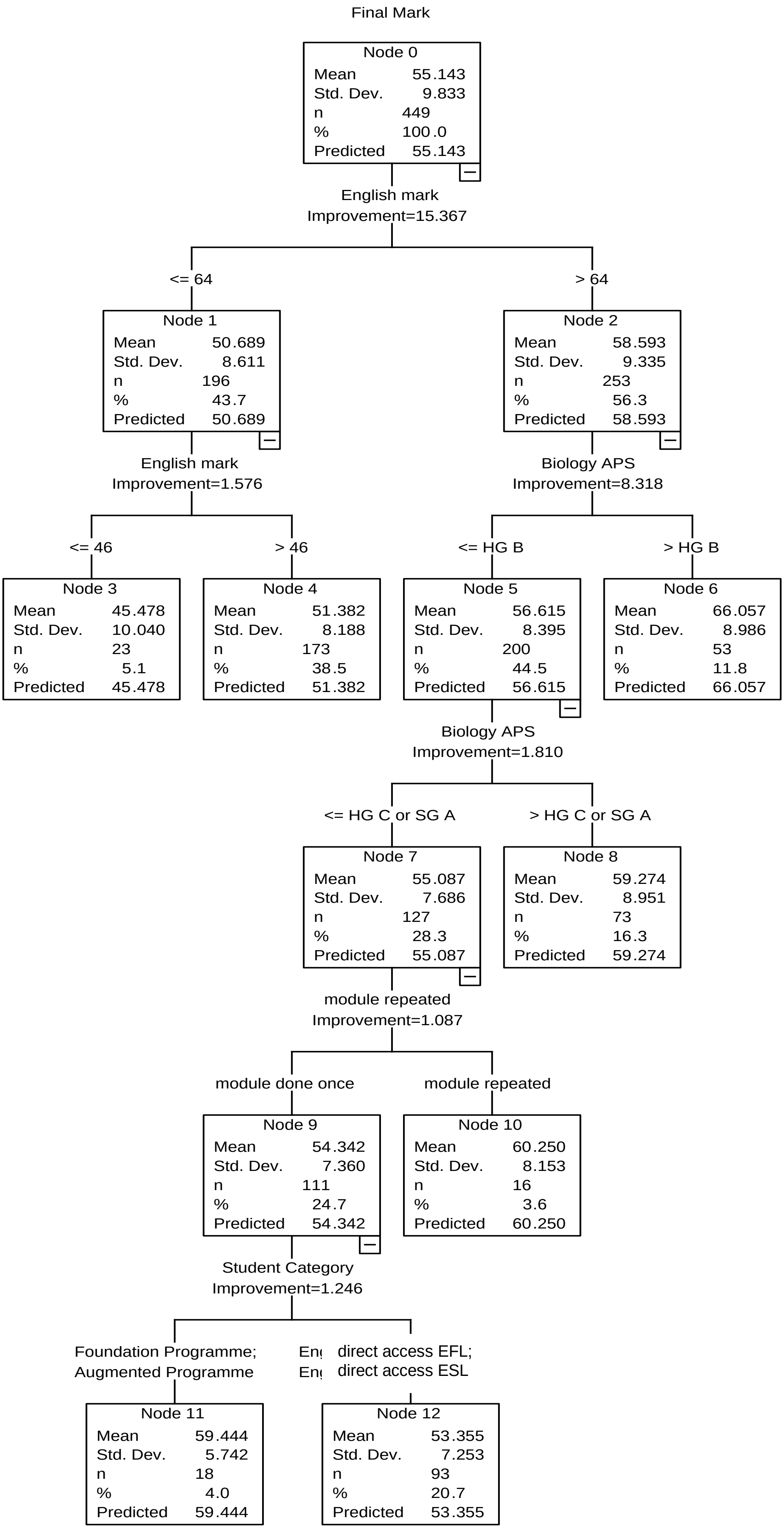

Figure 18. Regression tree for 2007 and 2008 final marks for BIOL 101 (*N* = 449). Only those students who studied Biology at school were included. Cohort and ethnicity were **excluded** in construction of the tree.

BIOL 101 Final Mark, 2009. In the generation of the initial 2009 regression trees, “matric year” was forced as the primary splitter of the root node to accommodate the change-over from the Senior Certificate to the National Senior Certificate (Figures 19 and 20). Here, school performance indicators referred to those applied for each system as described in Appendix A (pre-2008) and Appendix B (from 2008). Of the 352 students for whom a full set of data was available, 133 (38%) had finished school before 2008; 219 (62%) had written the NSC examinations. This variable improved the homogeneity of the daughter nodes by only 7% suggesting no major difference in performance between the two sets of students existed. Indeed, although the difference between those writing the NSC and the SC was significant (node 1, $M = 54.85$, $SD = 9.5$; node 2 $M = 49.41$, $SD = 9.29$), $t(350) = 5.29$, $p < 0.001$) (two-tailed), the effect is considered small, $r = 0.25$ (Field, 2009). Figure 19 reflects trends very similar to those in Figure 16 for the pre-2008 matriculants (node 1) in that the matric score distinguished performance amongst the White students and English language proficiency was more important in determining performance amongst the Black African and Indian students.

The National Senior Certificate appearred to be effective to some extent in removing the influence of ethnicity (node 2), the matric score of 34 being the cut-off value distinguishing those students who, on average, achieved well in the BIOL 101 module (node 6) from those who did not (node 5) (an exception being the few White students identified in node 11). Ethnicity did not even appear as a good surrogate for matric score here, the next most effective splitter of node 2 being English APS (improvement in purity = 5.93, λ coefficient for contingency tables = 0.23). This is edifying given that much research to date has found the matric score is a good indicator of potential for only some ethnicities (see earlier discussion).

The Augmented Programme students fared somewhat better in BIOL 101 than those Black African, Indian and Coloured students who achieved 34 NSC matric points or fewer in 2008 (node 14, $M = 49.03$, $SD = 7.83$; node 13, $M = 45.63$, $SD = 8.29$ respectively). Performance in the main group of Augmented students (node 14) was influenced by English language proficiency as indicated by school English APS.

The tendency for those mainstream English Second Language students achieving a score of 34 NSC matric points or fewer to be at risk of failing the first-year module was reinforced in Figure 20 where ethnicity had been removed from the tree. Here the influence of matric score was very clear, with those students in node 11, failing on average (M = 45.53, SD = 8.37). Those students who completed the Foundation Programme because of their poor Senior Certificate matric score (terminal node 14), were found to perform better in this first-year module than the Augmented Programme students (those that had done the NSC, node 12, and those who had gained a Senior Certificate, node 13) and also those English Second Language students who had achieved 34 NSC matric points or fewer and were admitted directly into mainstream (node 5). These results are similar to those reported in Chapter 5, but here more detail is discernable. It is apparent that those English Second Language students gaining 34 NSC points or less (and certainly those achieving fewer than 30 points) may have benefitted from completing a Foundation year prior to entering mainstream. This has implications for Faculty entrance requirements, given that students have been admitted to mainstream with NSC matric scores of 28 since 2009.

Given the dominant influence of matric scores in 2009 it should not be surprising that using only matric score and student category (whether they were ex-Foundation Programme, Augmented, DA-ESL or DA-EFL students) it was possible to fairly accurately predict performance in the 2009 module. Syntax for the classification rules was generated using only these variables from the 2007 and 2008 data; the resulting predicted and actual 2009 BIOL 101 results correlated significantly well ($r = 0.41$, $p < 0.01$), this being considered a medium to large effect (Field, 2009).

In an attempt to explore the 2009 cohort as a whole, without the influence of the different matriculation systems, Figure 21 was generated using “matric score equivalent” and “APS equivalent” scores generated using Appendix C. Here, all pre-2008 scores were converted to be equivalent to 2008 NSC scores. The influence of English language proficiency, suggested in Figures 19 and 20, came to the fore here. Irrespective of the year of matriculation and ethnicity, higher levels of English language proficiency (as indicated by school English APS) resulted in better performance in this mainstream module. Given that students gaining an NSC need to have achieved a level 4 in school English, these results suggest that English language proficiency remains an obstacle for the majority of students of all ethnicities, and as such is an area that may be considered for curricula reform. What may also be construed by this tree is that those students completing the Foundation Programme prior to entering mainstream did benefit in respect to improving their English proficiency in that this group performed as well as those Black African, Indian and Coloured students leaving school with higher English scores (node 9, $M = 53.68$, $SD = 5.36$; node 6 $M = 54.27$, $SD = 8.32$), $t(50) = 0.27$, $p > 0.05$) (two-tailed), $r = 0.04$. Those trees generated with the subset of 2009 students who had studied biology/life sciences at school ($N = 325$) revealed that performance in the latter school subject from 2008 was a very good indicator for performance in the mainstream module, replacing matric score as primary splitter of node 2 in Figures 19 and 20, and English APS equivalent in both nodes 1 and 2 in Figure 21 (ethnicity and matric score retained their positions as primary splitters of node 1 in Figures 19 and 20 respectively) (trees not presented). Relative to Figure 18 that showed that English proficiency was even more important than performance in school Biology, this suggests that the NSC Life Sciences curriculum is perhaps a better indicator of success in mainstream Biology than the school Biology curriculum has been in the past. This was found to be a generally consistent trend across the ethnic groups where year of matriculation was not distinguished in a forced split of the root node, and “score equivalents” were used in tree construction (Figure 22). It should be noted however, that school biology/life science is not a pre-requisite for the first-year module, BIOL 101.

Notably school Mathematics did not appear as a primary splitter in any tree above; nor was it the best available surrogate in splitting any higher nodes (in particular nodes 1 and 2).

Overall school performance (as indicated by matric score) in the NSC appears to be a better predictor of success in this mainstream Biology module than the former Senior Certificate for ALL groups of students, not only for those who have traditionally scored the best in the school leaving exams (White students and those with higher levels of English language proficiency). As reliable an indicator as the NSC matric score appears to be however, the values of the Faculty’s admissions criteria for each stream could be reviewed to the benefit of many students who currently are not able to take advantage of completing a Foundation Programme in an Access year. This speaks to a widening of Access at UKZN.

Widening “Access” may also be viewed in terms of remedial action in the mainstream curriculum. In spite of selection criteria having been extended to include level 4 for school English in 2009, English language proficiency appears to remain an obstacle for the majority of students in the BIOL 101 module, irrespective of year of matriculation, ethnicity or access route to mainstream; as such it is an area that may be considered for curriculum reform.

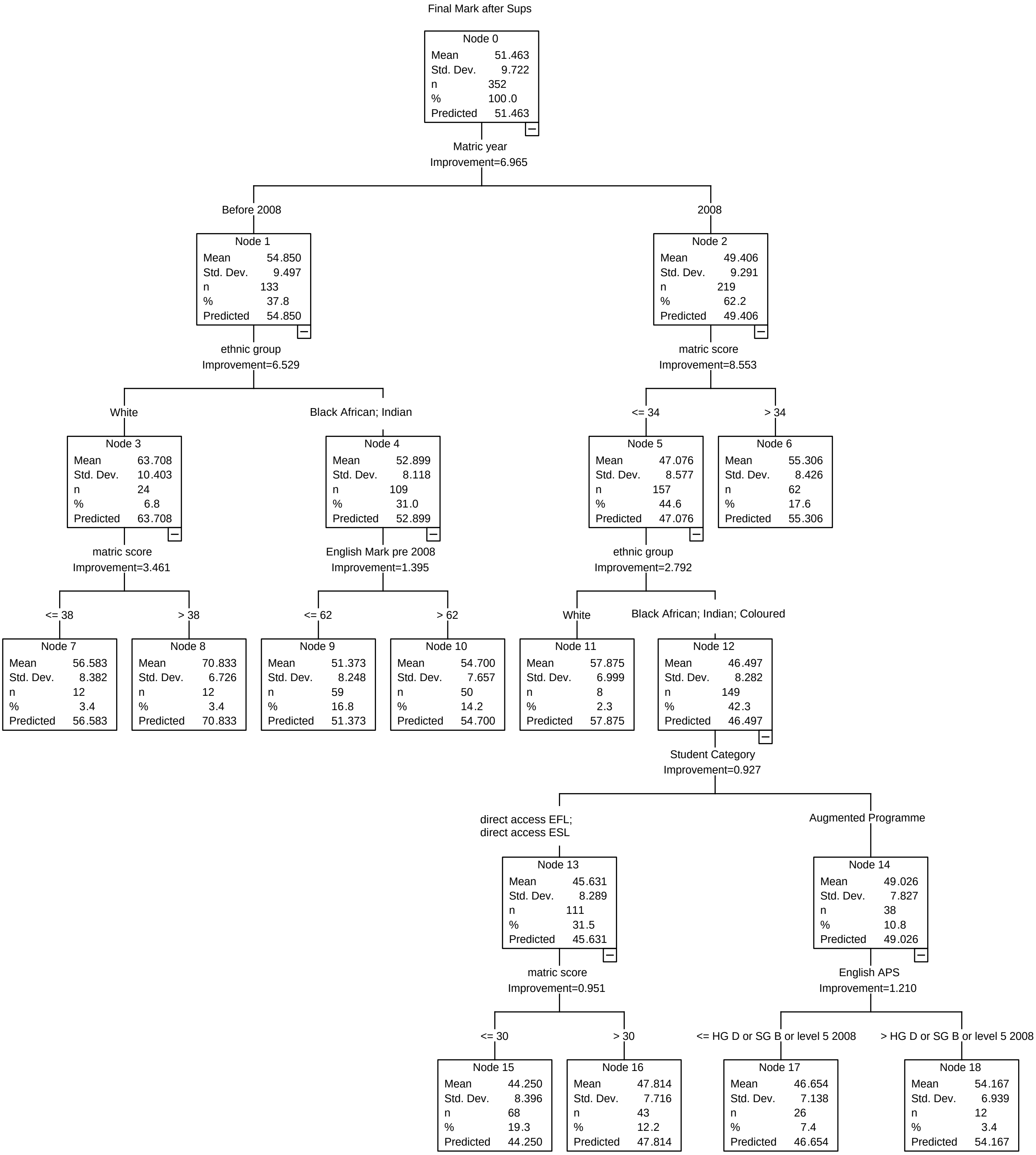

Figure 19. Regression tree for 2009 final marks for BIOL 101 (*N* = 352). Students who did not study biology/life sciences at school were included. Year of matriculation forced for first split; Matric scores and APS applicable to each year (SC not made equivalent to NSC). Ethnicity was included in construction of the tree.

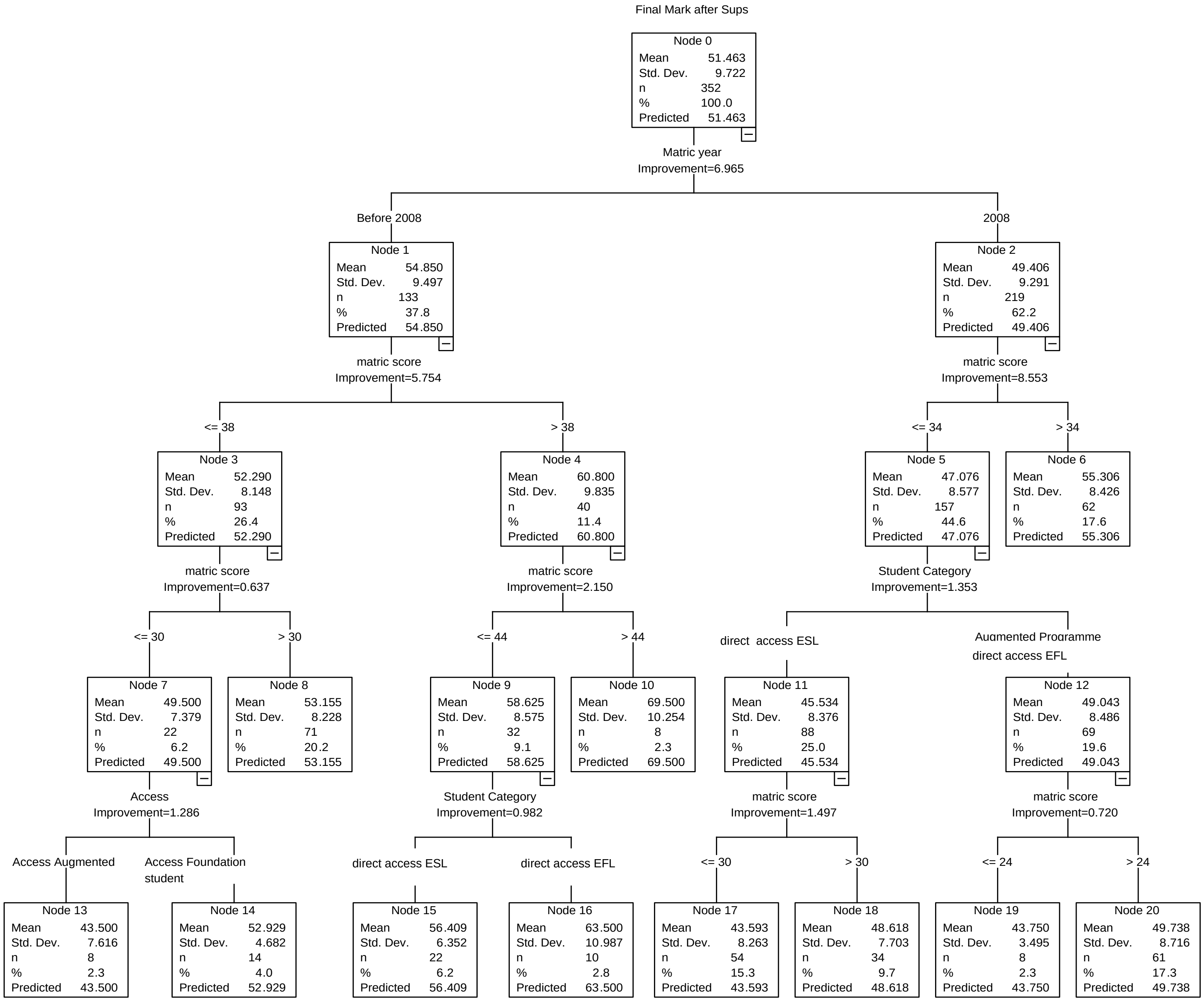

Figure 20. Regression tree for 2009 final marks for BIOL 101 (*N* = 352). Students who did not study Biology/ Life Sciences at school were included. Year of matriculation forced for first split; Matric scores and APS applicable to each year (SC not made equivalent to NSC). Ethnicity was **excluded** in construction of the tree.

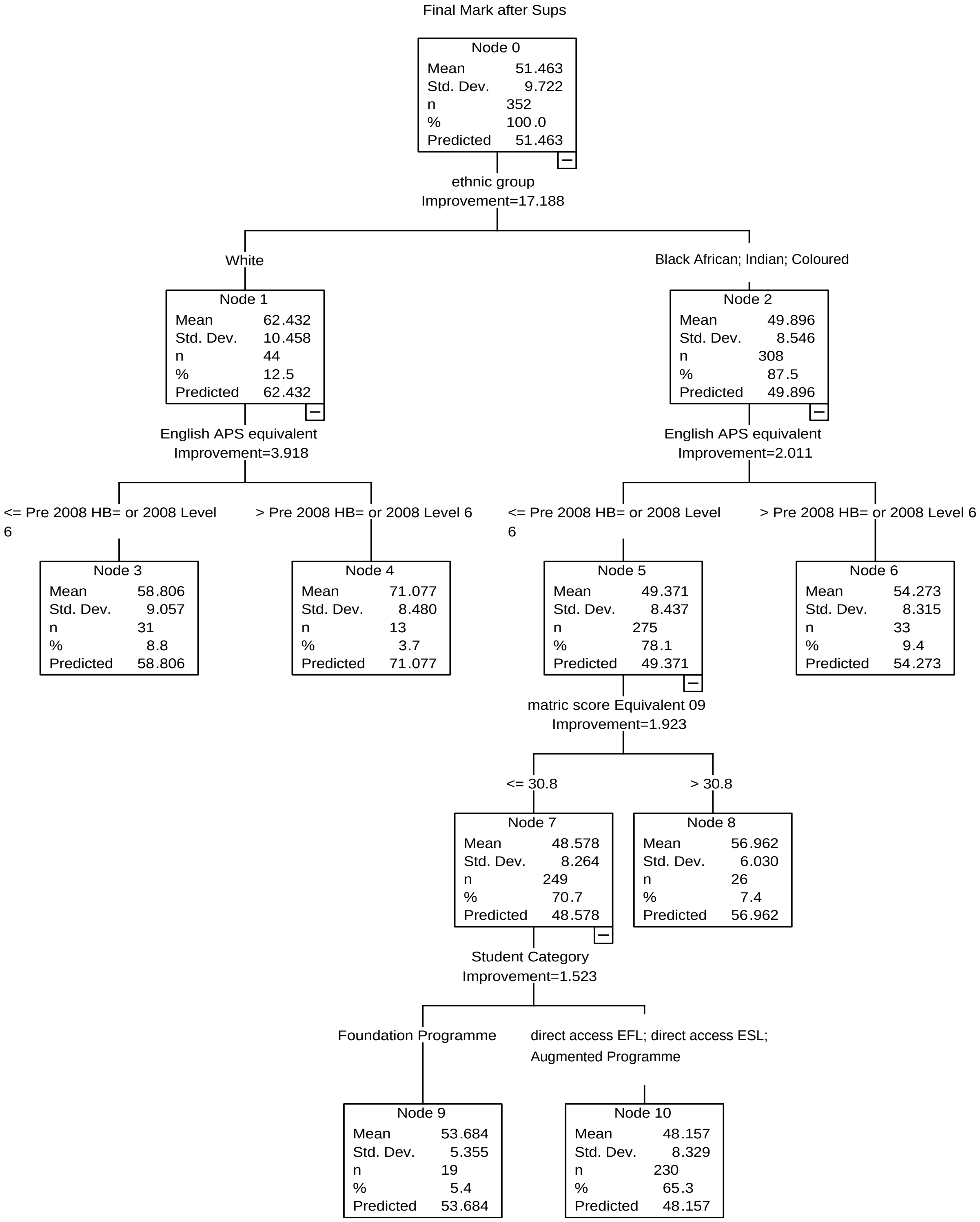

Figure 21. Regression tree for 2009 final marks for BIOL 101 (*N* = 352). Students who did not study biology/life sciences at school were included. Distinction not made between years of matriculation; SC matric scores and APS for each subject made equivalent to NSC (see Appendix C). Ethnicity was included in construction of the tree.

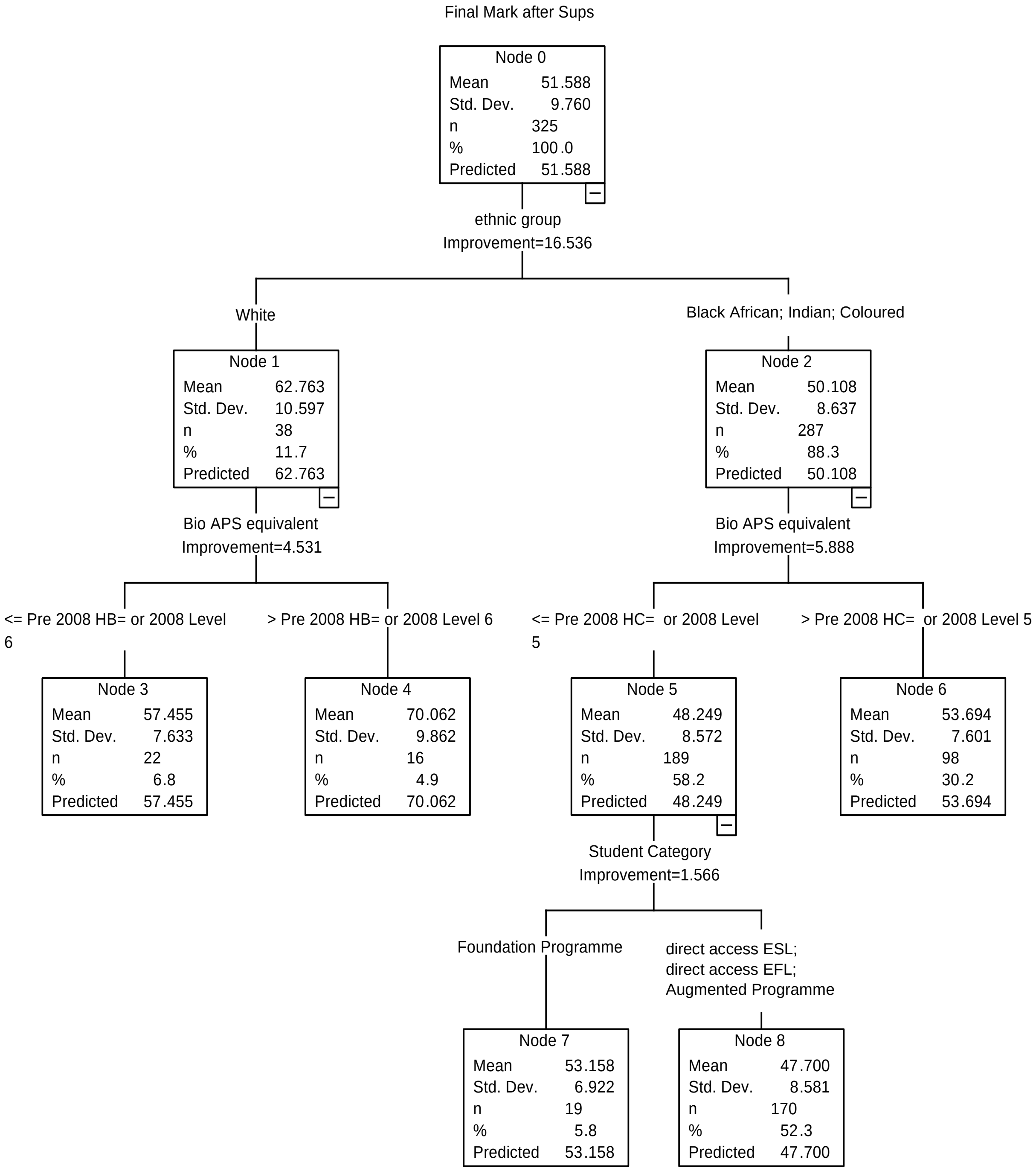

Figure 22. Regression tree for 2009 final marks for BIOL 101 (*N* = 325). Only those students who studied biology/life sciences at school were included. Distinction **not** made between years of matriculation; SC matric scores and APS for each subject made equivalent to NSC (see Appendix C). Ethnicity was included in construction of the tree.

BIOL 101 Continuous Assessment Mark and Theory and Practical Exams. Regression trees for BIOL 101 continuous assessment marks and theory and practical exam results are provided in Figures 23 to 29. For the most part, they represent the performance of all 478 students in 2007 and 2008, and 352 students in 2009. Growth limits (to a depth of three levels and a minimum change in improvement of 1) were set for these trees, in an attempt to simplify them to represent the main trends only. To this end, "cohort" (in the 2007 and 2008 trees) was excluded in tree-generation; year of matriculation in the 2009 trees, although included, was not forced as the primary splitter of the root nodes. Furthermore, with respect to the latter where students from both the SC and NSC schooling systems were present, matric "score equivalents" were substituted for the discrepant years from each cohort (Appendix C). The influence of ethnicity was also excluded, this variable being considered unhelpful in identifying areas of possible remediation in the Biology module.

For those 2007/08 students for whom English is a first language, matric score influenced their continuous assessment mark the most. Conversely, the Access and direct access English Second Language students were most affected by their school English mark (nodes 5 and 6, Figure 23). Those students who had better levels of English language proficiency and were entering mainstream via Access routes (node 10) performed better than the majority of DA-EFL students (node 3). The students in node 2 who had weaker school English marks were subsequently distinguished by matric score (nodes 7 and 8). Given that "student category" was found to be a very good surrogate for matric score (improvement in purity = 2.71, λ coefficient for contingency tables = 0.88), it can be assumed that node 7 (the weaker matric scores) includes the balance of the Access students. Students here (node 7), performed adequately well in the continuous assessment component of the BIOL 101 module, in spite of their lower matric scores and lower levels of English language proficiency. Maths APS was found to be a reasonable surrogate only in splitting node 1, the DA-EFL students (improvement in purity = 2.74, λ coefficient for contingency tables = 0.5). Whether students had studied Biology at school or not was not found to have sufficient impact on performance to be a primary splitter. Furthermore, school Biology performance in the subset of students who had done this subject (N = 119) was not sufficiently influential to be a primary splitter of any node, the tree generated being almost identical to Figure 23.

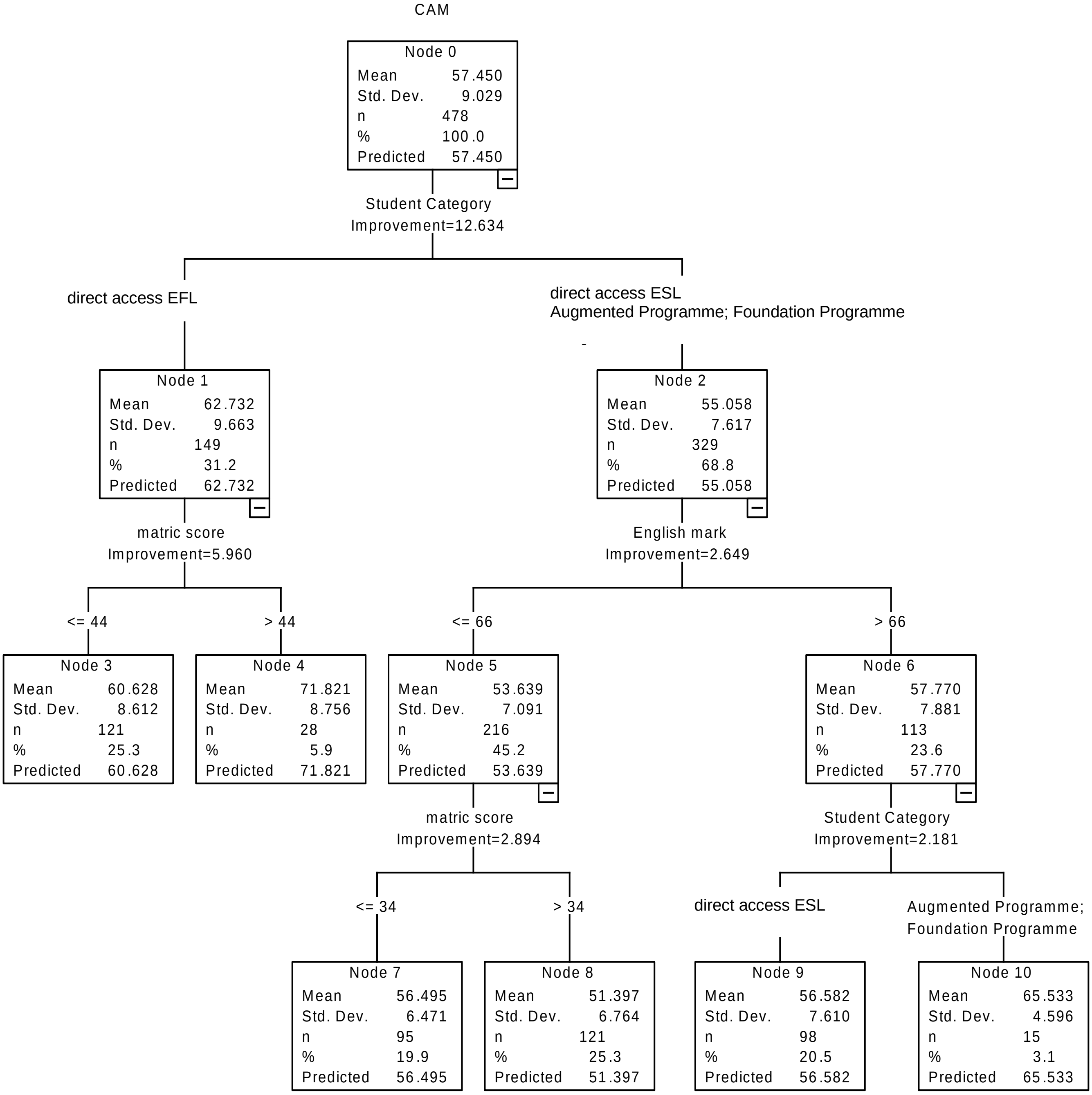

Figure 23. Regression tree for 2007 and 2008 continuous assessment marks (CAM) for BIOL 101 (*N* = 478). Students who did not study Biology at school were included. Cohort and ethnicity were **excluded** in construction of the tree.

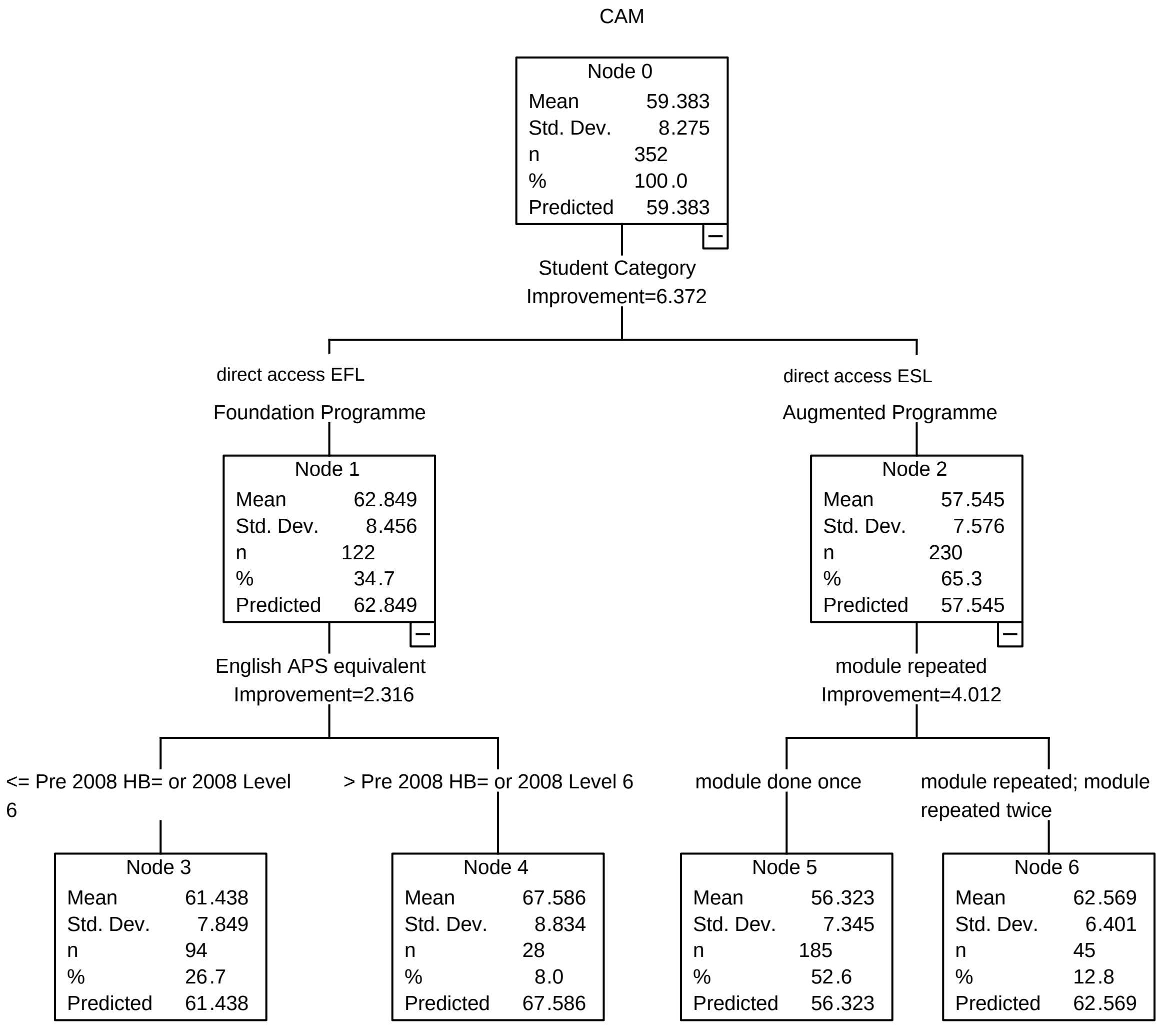

Figure 24. Regression tree for 2009 continuous assessment marks (CAM) for BIOL 101 (*N* = 352). Students who did not study biology/life sciences at school were included. Distinction was **not** made between years of matriculation; SC matric scores and APS for each subject were made equivalent to NSC (see Appendix C). Ethnicity was **excluded** in construction of the tree.

Similarly in the 2009 cohort, “student category” was the primary splitter of the root node of the CAM results (Figure 24), although not to the same extent, reducing the heterogeneity in the root node by only 9.3%. Although overall the continuous assessment marks for **all** students was high (mean of 59.3%), the ex-Foundation Programme students appear to have done better than the Augmented Programme students and those direct access students for whom English is a second language. Had those students in node 3 had better school English marks, it may be assumed that their continuous assessment marks would be more like those in node 4, given that English APS is the primary splitter of node 1 in this tree. In the subset of 325 school Biology students, Biology APS was shown to be a slightly better primary splitter of the root node than “student category” (improvement in purity = 6.95), although “student category” remained the most important variable in the tree overall (normalised importance of 100%). This tree (not presented) indicated that those students achieving more than a higher grade C (or a standard grade A) in the Senior Certificate or a level 6 or more in the NSC (*n* = 126, *M* = 62.69, *SD* = 8.16) achieved better continuous assessment marks than those who achieved less than this at school (*n* = 199, *M* = 57.27, *SD* = 7.81). This was reflective of trends seen in Figure 22 for final mark.

Results illustrated in Figure 25 for the practical exam results of 2007/08 reflect the findings of the discriminant function plots (Figures 10 and 11). With “student category” splitting the root node (variance of 157.57), the impurity change (27.63) represented an 18% improvement in purity in the resulting nodes. Whether students had done English as a first or second language at school was found to be a moderately feasible surrogate for splitting the root node (improvement in purity = 21.24, λ coefficient for contingency tables = 0.45) and whilst resulting in similar improvement in purity in splitting node 1 (6.7 in comparison to 8.75 shown by English mark) had poor association with the primary splitter used (λ coefficient for contingency tables = 0.13). The ex-Foundation students did noticeably better in the practical exam than the Augmented stream or direct access English Second Language students, and according to this tree were not as affected by their levels of English language proficiency as were the latter (node 1). No other factors were found to be feasible surrogates in splitting either the root node or the resulting nodes 1 and 2. Furthermore, in the subset of students who had all studied school biology/life sciences, the APS for this subject was not revealed as a primary splitter or even as a viable surrogate for those variables reflected in Figure 25.

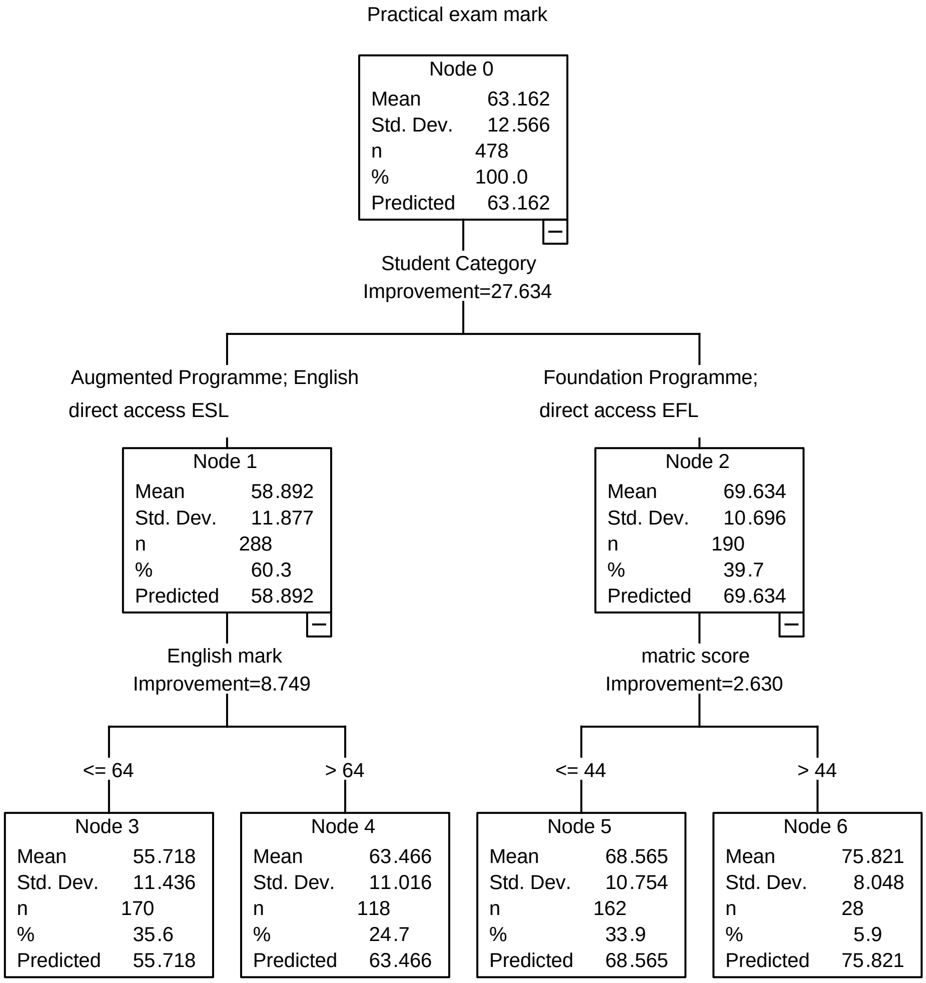

Figure 25. Regression tree for 2007 and 2008 practical exam marks for BIOL 101 (*N* = 478). Students who did not study Biology at school were included. Cohort and ethnicity were **excluded** in construction of the tree.

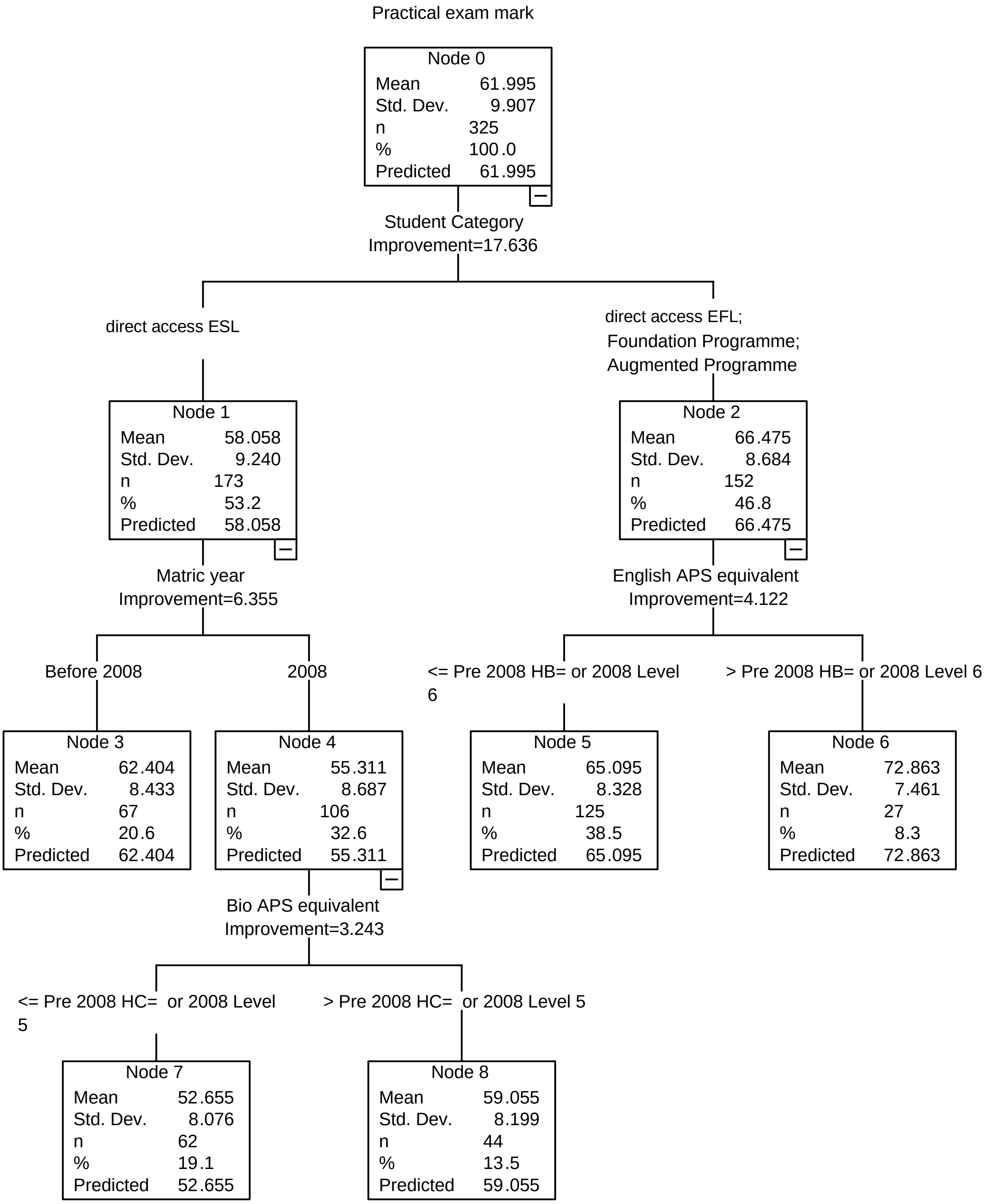

Figure 26. Regression tree for 2009 practical exam marks for BIOL 101 (*N* = 325). Only those students who studied biology/life sciences at school were included. Distinction was **not** made between years of matriculation; SC matric scores and APS for each subject were made equivalent to NSC (see Appendix C). Ethnicity was **excluded** in construction of the tree.

Figure 26 shows the practical exam results for the 325 students in the 2009 mainstream cohort who did study school biology/life sciences. The tree that included those who had not done these subjects at school was identical except for the addition of the split of node 4 made by Biology APS seen in Figure 26. The tree presented thus gives the opportunity to see the influence of the NSC Life Sciences on direct access English Second Language student performance in the practical exam (node 4); this is interesting, given that the influence of school Biology has been, for the most part, minimal until now[11]. In the 2009 practical exam results, the Augmented Programme students appear to have done similarly well to the ex-Foundation Programme students; all students in this group, irrespective of access route, were subsequently influenced by their English proficiency (as reflected by school English APS) (node 5).

Relative to the within-node variance of the root for the 2007/08 theory exam (141.15), the homogeneity in the groups of students achieving a matric score of 42 or less was increased by 21% by school English mark (Figure 27). On average, for those students in node 1, their English language proficiency as indicated by school mark in this subject distinguished those whose failure in the theory exam was borderline (terminal node 4, *M* = 49.4, *SD* = 10.06) from those whose likelihood of failure was much higher (terminal node 3, *M* = 43.60, *SD* = 10.69). Those achieving more than 42 matric points had a much better chance of passing the first-year Biology theory exam, with those few students scoring more than a higher grade B in matric maths doing the best (terminal node 6, *M* = 72.67, *SD* = 7.56). In the group of students who had all studied Biology at school (*N* = 449) performance in this school subject had little apparent influence since it was not a primary splitter, nor a good surrogate for splitters indicated.

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[11] Incidentally, Marshall (2010) has noted that students writing the NSC are more confident and engaged in laboratory work in first year courses than has previously been found. A future study investigating the practical implementation of the NSC LO1 (“doing Science”) in schools may be found to be most interesting since anecdotal evidence suggests that very few teachers are actually doing practical work in class.

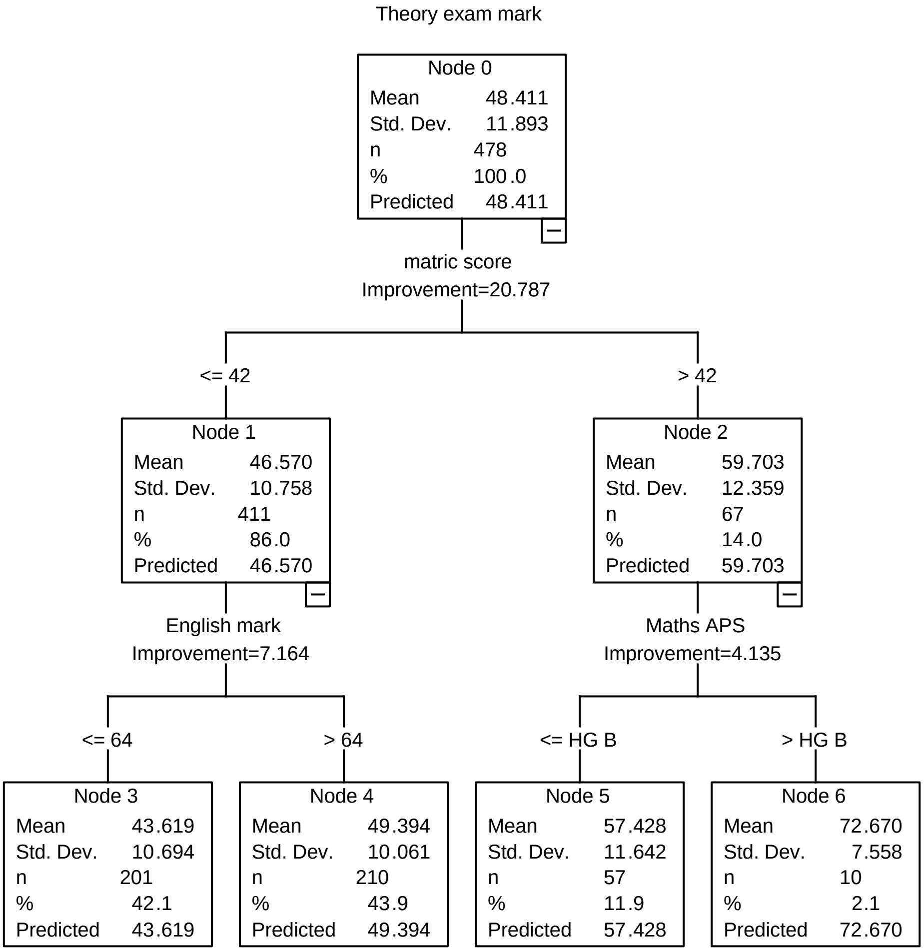

Figure 27. Regression tree for 2007 and 2008 theory exam marks for BIOL 101 (*N* = 478). Students who did not study Biology at school were included. Cohort and ethnicity were **excluded** in construction of the tree.

In the 2009 tree that included all the students in the cohort (Figure 28), the reduction in impurity by English APS, revealed as the primary splitter of the root node, was only 7%. This was largely because only those few students who scored the highest possible English scores (HG A or level 7) passed the theory exam (node 2), the bulk of the students (*n* = 304) failing on average. Those students who had written the NSC in 2008 did particularly badly (terminal node 4, *M* = 37.96, *SD* = 11.367).

The influence of the NSC is even clearer in Figure 29. School biology/life sciences reduced the within-node variance of the root (166.15) by 14%, double that of school English APS. In part, this new dominance of Life Science APS over English APS must surely be a consequence of the admissions criteria being extended to include level 4 English, but it may also indicate the influence of improved predictive value of the NSC Life Science APS alluded to before (63% of those students who had studied school biology/life sciences had written the NSC rather than the SC).

However, what was also evident is those students who did do the NSC performed much worse than those who had completed Biology in the Senior Certificate, particularly if they had achieved lower than a level 5 NSC in this school subject (node 3, *M* = 34.98, *SD* = 10.50; node 4, *M* = 41.58, *SD* = 10.19). Even those scoring highly in biology/life science at school, and being non-Zulu or Xhosa speaking, did poorly if they had completed the NSC rather than the Senior Certificate (node 11). With respect to the ex-Foundation students in particular, their Access year has clearly not sufficiently prepared them for this component of the mainstream module. For all terminal groups in fact, except those few who had matriculated before 2008, with good Biology scores, and whose home language was not Zulu or Xhosa (node 12), the theory exam remains a particular challenge. Given that other students in the module will not even have done biology/life sciences before arriving at University, it appears that there is still a need for remediation in the curriculum that will address the negative influence of poor English proficiency (as suggested by school English APS).

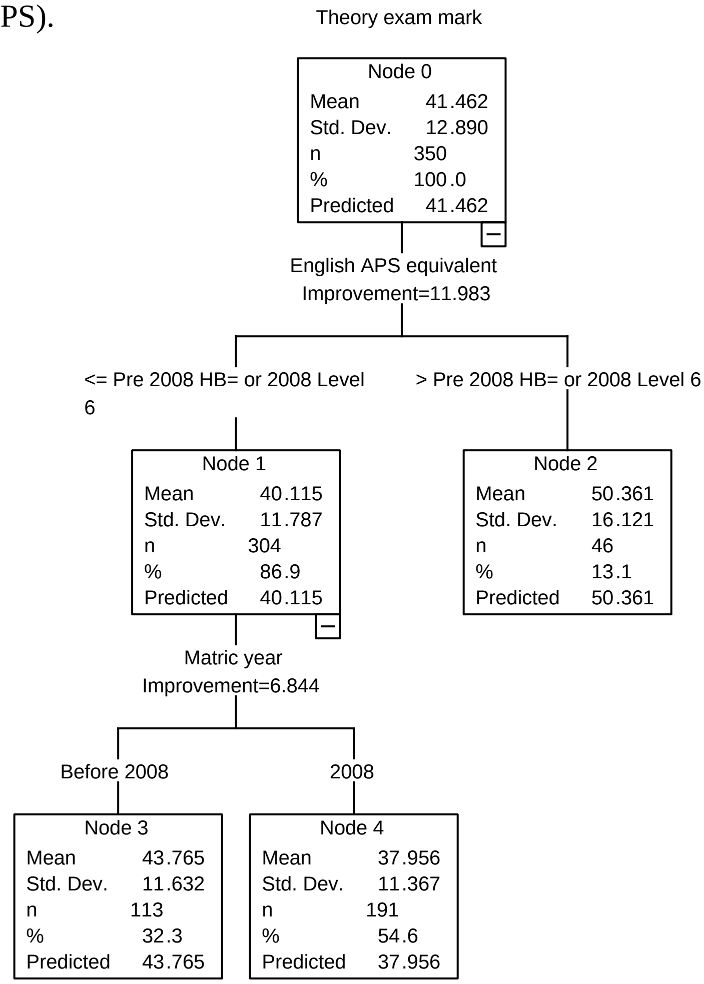

Figure 28. Regression tree for 2009 theory exam marks for BIOL 101 (*N* = 350). Students were included who did not study biology/life sciences at school. Distinction was **not** made between years of matriculation; SC matric scores and APS for each subject made equivalent to NSC (see Appendix C). Ethnicity was **excluded** in construction of the tree.

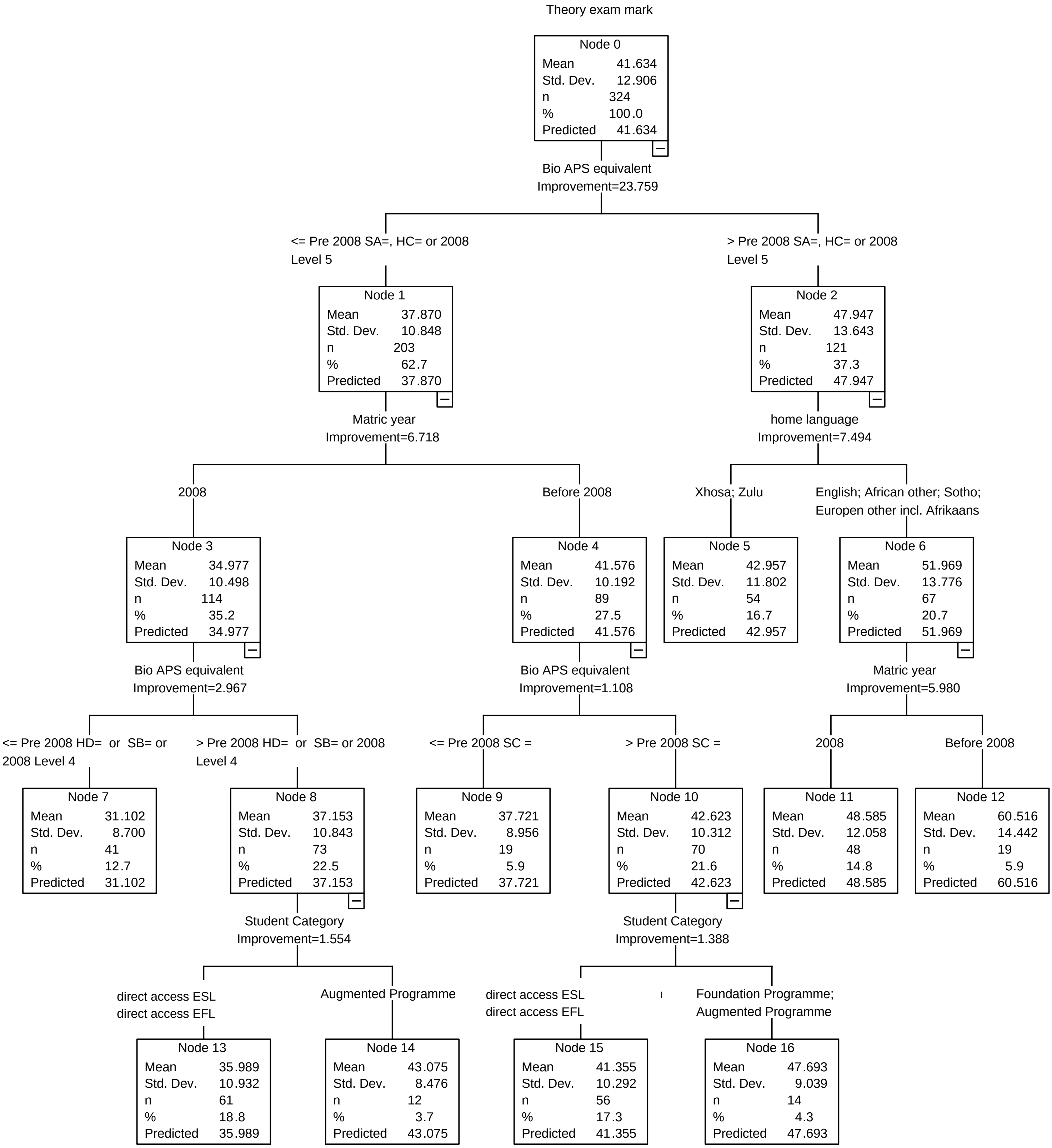

Figure 29. Regression tree for 2009 theory exam marks for BIOL 101 (*N* = 324). Only those students who studied biology/life sciences at school level were included. Distinction was **not** made between years of matriculation; SC matric scores and APS for each subject were made equivalent to NSC (see Appendix C). Ethnicity was **excluded** in construction of the tree.

Performance of pre-NSC cohorts of students suggests that both Access routes (Augmented and Foundation streams) advantaged those who had completed them over other English Second Language (direct access) students in terms of continuous assessment. Students that have passed through the Foundation Programme, however, appear to continue to perform well in the continuous assessment component, and are advantaged over the Augment and direct access English Second Language students of 2009, the majority of whom have done the NSC. In terms of practical skills, the Foundation Programme reliably provides its students in mainstream, a competitive edge over the Direct-Access English Second Language students, irrespective of the schooling system the latter have passed through. The continuous assessment and practical exam performance of those weaker students who have traditionally entered mainstream or the Augmented Programme may benefit undeniably by the skills and resources gained in completing a foundation year. The issue of English language proficiency, which in part has already been addressed by the implementation of additional Faculty selection criteria, continues to remain a particular challenge to improving performance in the theory exam, and thus is an area for curriculum revision. This will extend epistemic access to include those students who are not traditionally labelled as "Access" students, others who are admitted to mainstream but apparently not given access to success.

CHAPTER 7

Factors Influencing Performance of Students in a First-Year Biology Module

Reflection, Taking the Grounded Theory Forward and Opportunities for Remediation

The Widening of "Access". Mainstream Curriculum Responsiveness – Lessons from a traditional Access programme

The major departure point for discussion at the ASSAf (Academy of Science of South Africa) "Mind the Gap" forum in Cape Town in October 2010 was the need for a tertiary mainstream response to the articulation gap acknowledged to exist between school and higher education in South Africa (see for example DOE, 1997a). This gap has long been recognised to exist, particularly in students entering tertiary education from former DET (Department of Education and Training) schools (Grayson, 1996; Rollnick, Manyatsi, Lubben & Bradley, 1998; Mumba, Rollnick & White, 2002), but there has been renewed, intensified interest in it with the introduction of the NSC (Marshall, 2010). Traditionally, responsiveness has been directed at the level of secondary schooling (Reddy, 2006c; Yeld, 2003), and in the establishment of foundation programmes (already discussed in detail) at tertiary level (for example Rollnick, 2006), but there is a growing sentiment that there is an urgent need for mainstream programmes to play a part in "minding the gap" too. Although this is particularly pertinent in South Africa where issues are coloured by the inequities of our apartheid past, this call for mainstream responsiveness has been made internationally. Massification of higher education is a global phenomenon (Breier, 2001) and amid the growing concerns about retention and attrition rates, there has been an increase in the focus on teaching and learning, a change in pedagogical perspectives rather than responses based on a deficit view of the student (Haggis, 2006).

Mainstream responsiveness and "normalising the norm". This view of the student being "disadvantaged" was indeed contested at the ASSAf forum with some putting forward the notion that it is worth considering the university as "under-prepared", rather than this term being applied to students entering tertiary education (Collier-Reed et al., 2010). It was argued that "we should not be proud of our high failure rates, nor of our largely unchanged first-year courses" (Engelbrecht, 2010). Indeed, there is currently a great deal of evidence that across the tertiary sector in South Africa there are high levels of attrition at first-year level, low overall completion rates and the majority of students do not complete their degrees in the minimum regulation times (Scott et al., 2007). Scott (2010) reports that nationally, only 21% of life and physical sciences students of the 2000 intake completed their degrees in the stipulated three years. Similarly, sharp declines in pass rates in mathematics and science courses have been reported over the past decade (Collier-Reed et al., 2010; Engelbrecht & Harding, 2010; Hunt et al., 2010; Jacobs & de Bruin, 2010; Potgieter & Davidowitz, 2010), a trend that can not only be accounted for by the introduction of the National Senior Certificate in 2008. Certainly, this decline in performance has been witnessed in the BIOL 101 module from 2007 through to 2009 described in the previous chapters (even though slightly higher matric scores for the 2008 cohort were recorded than for the previous year's intake; see Chapter 5).

Furthermore, students entering mainstream university study in the past few years in this country have been found to have poor general quantitative and (language) literacy skills (Potgieter, 2010), and Winberg (2010) describes the problems experienced by students in the 2009 mainstream cohort as being at a fundamental level with respect to interpretation of questions, written expression and logical approaches.

Given the scenario described above, and that any changes in secondary schooling will take time (Chisholm, 2010; Kloot et al., 2008), the call for mainstream responsiveness was made. It was acknowledged that the students currently entering first year in South Africa are, in fact "cream of the crop" (Collier-Reed et al., 2010; Marshall, 2010), and in a country where participation levels in tertiary education are already unacceptably low (Scott et al., 2007 estimate that gross participation rates in South Africa's higher education system are as low as 16% in the 20-24 year age group), simply raising entrance requirements using the school leaving measures of performance is not the solution. Thus, with increased admission criteria not the most viable option, the call for higher education institutions "to teach students we have, not those we wish to have" (Chisholm, 2010) must be responded to in a scholarly and informed manner.

The forum identified three levels at which mainstream responsiveness would be required: at the levels of curriculum, pedagogy and institutional culture. Scott (2010) emphasised the possibility of a rethinking of entire undergraduate programmes to include pedagogical practices and curricula innovations traditionally found only in foundation programmes. This speaks, at the curricular level, to the notion of a four-year standard degree in South Africa, and indeed, there was widespread support for the "normalisation of the norm", given that the majority of students do not complete their degrees in the given three years (as reported by Scott and colleagues) (see also Marshall, 2010). This issue has been increasingly debated in national government forums (e.g. Strydom & Mentz, 2010) and given much attention too in the popular media (for example Blaine, 2010; Dell, 2010; Gernetsky, 2011; Gower, 2008; Serrao, 2008).

As described in Chapters 5 and 6, the completion of an access year in the Foundation Programme advantages successful students (despite their lower initial entrance marks) over many others who are not offered this opportunity because they enter mainstream directly or through an augmented curriculum. Moreover, many students who have been admitted directly to mainstream may have benefited from doing the Foundation Programme.

This study does not seek to give clarity on which particular aspect of the Foundation Programme contributed to the success of the students who passed through it. It may be speculated that some students benefited most from the development of their practical skills, others from the development of their English language proficiency in the context of science; some may have benefited most from the advancement of their metacognitive skills in particular, and therefore have developed a deeper approach to learning. Their academic and social involvement in their access year may have mediated their integration into mainstream (as reported by Tinto, 1998); past studies show that foundation students gain in confidence (Downs, 2005). No doubt, many would have benefited from having been given the necessary support to make the transition to mainstream study successfully (see Chapter 4; Pitkethly & Prosser, 2001; Tinto, 2005).

No matter which aspects of the Foundation Programme contribute most profoundly to the advantage these access students have, the results of this study show that the "foundation package" is indeed, successful. And this supports the idea of a four-year degree for more students than is currently the case – if the first of the four years took on the form of the Foundation Programme. But, given the resource intensive nature of the programme (UKZN, 2008), and the large sizes of current first-year classes, this is unlikely to be a feasible option. Amongst others, Holtman, Marshall and Linder (2004) have acknowledged the difficulties in attempting to provide an intensive level of foundational support on a large scale.

The location of the Foundation Programme towards the periphery of mainstream thus constrains access to the broader first-year life sciences community. No doubt the integration of foundation educational principles into the mainstream curriculum and teaching would serve to benefit many students and the University alike as higher pass rates could be expected. This would be especially effective in the instance of "high impact" modules such as the BIOL 101 module at UKZN. Engelbrecht (2010) reports that in the Science Faculty at the University of Pretoria, such high impact modules were identified, support for pedagogy and curriculum change provided and recognition given for the time and effort involved in making the response. The results of this have been pleasing (ibid.).

This tendency towards the "infusion model" in mainstream is what Grayson (1997) alluded to when the original Science Foundation Programme was being piloted in the early half of the 1990s. The "infusion model" (see Volbrecht & Boughey, 2004) sees academic development as integral to all years of a mainstream programme. At some South African institutions this has been the approach to access for some time; at the University of the Western Cape such innovations have included the integration of language development into the mainstream curriculum, small group learning in large classes, and interventions that promote a deep approach to learning (Holtman et al., 2004). Indeed, as Marshall (2010) points out, there is a strong movement towards socio-cultural perspectives in Science, Technology, Engineering and Mathematics education (STEM), and the need for the development of mainstream curricula that take these perspectives on learning into account has been strongly voiced. Of course, as has been laid out in Chapter 4, this educational perspective is at the basis of the Foundation Programme.

Nearly two decades after Grayson and her team foresaw the need for infusion, this study again calls for a "mainstreaming" of foundation principles. This perhaps follows a natural progression given the dramatically changed demographics of the University of KwaZulu-Natal over this period. Certainly when the Foundation Programme was initiated in 1991 the vast majority of the University's population was White and English First Language; over the period of the present study (2007-2009), the number of Black African students in the Faculty of Science and Agriculture had grown to be three to four times the number of White students (Division of Management Information, 2011). The vast majority of these Black African students admitted directly to mainstream identify themselves as English Second Language speakers (98.1% in the 2007/2008 cohort and 97.4% in 2009). It is to many in this group that Access needs to be extended as currently they are ironically disadvantaged by achieving higher university entrance grades at school.

These delays in progressive change proposed decades earlier have been identified elsewhere in South Africa. Volbrecht and Boughey (2004, p. 65) propose that this may be a consequence of the fragmented approach to academic development in this country (and within individual institutions); they identify the limitations on the implementation of curriculum reform without concomitant change at the institutional level. Kloot (2009) would contest that this obdurate phenomenon is actually a manifestation of Bourdieu's theoretical framework of social reproduction and the perpetuation of inequality.

As Boughey (2007) (quoted by Kloot et al., 2008, pp. 811-813) has found, although the Department of Education's (2006) funding strategy has clearly signalled the Government's preference for an integrated approach to foundational provision over separate foundation initiatives, this has still to be translated into meaningful structural change on the ground. Boughey claims that, in responding to the Government's (2006) funding framework, most degree programmes in South Africa were found to be structurally no different from those developed in the 1990s (Kloot et al., 2008, p. 811); it appears that UKZN must be counted amongst these. Indeed, as Volbrecht and Boughey (2004) point out, academic development in South Africa has arguably entered a new phase, that of "higher education development".

The current research, together with other research being done in this field in South Africa, suggests that it really is time for a fundamental restructuring of foundational provision within the context of the mainstream Life Science biology module, this module's relationship with Access and academic development within the Faculty's programmes as a whole. Indeed, many academics teaching mainstream first-year modules in South Africa are currently calling for this systemic change (e.g. Collier-Reed et al., 2010; Englebrecht, 2010; Holtman et al., 2004; Jacobs, 2010; Scott, 2010; Slonimsky & Shalem, 2004; Volbrecht & Boughey, 2004). This would contribute to realising the establishment of conditions, primarily institutional commitment that would enhance student persistence as described by Tinto (2005).

In addition to the integration of foundational principles into high impact mainstream modules, it is apparent that there is also a need for a more nuanced approach to admissions; the link between learning pathways and admissions criteria needs to be emphasised. The classification and regression trees presented in the previous chapter, and the grounded theory that emerged from them suggest that a more layered approach to admissions might be helpful. In light of the finding that the 2009 NSC matric points appear to be a fairly reliable indicator of potential in the high impact module investigated, these tools and theory suggest that:

- All prospective students, except those with particularly high matric points and/or those with very high levels of English language proficiency would benefit from extra foundational provision in the area of language literacy to improve their performance in the theory exam.
- English Second Language students (including those currently in the Augmented Programme in some instances) would benefit from foundational provision in mainstream with regard to performance in the continuous assessment component, (and particularly the performance in the practical exam/ component thereof). It appears that this would be particularly so in instances where students' English proficiency levels were poor.
- English Second Language students (including those who are currently in the Augmented Programme) whose matric entrance points were at the lower end of the range (below 30) would benefit from doing the stand-alone Foundation Programme before attempting mainstream.

On a practical level, this would require a revision of the Faculty's current admissions criteria for each stream. On a deeper level it could be argued that epistemic access for more students could become a reality. It is worth noting here (in context of the case made at ASSAf forum for not increasing admissions criteria) that this would effect a shift upwards of entrance criteria at the lower end of the admissions spectrum as programmes normally reserved for Access students would be filled by those currently accepted directly into mainstream. It is also worth noting that the Faculty entry requirements into mainstream at UKZN are generally below those of other major South African universities – for example 28-33 points are required for entry into the General Entry Programmes for Science (GEPS) (the extended curriculum) at UCT.

Mainstream responsiveness and language literacy. In terms of the second level of mainstream responsiveness identified at the ASSAf "Mind the Gap" forum, namely pedagogical practices, there are also lessons that can be learned from the CSA Foundation Programme. At the forum, with regard to 'language issues', there was widespread consensus that "academic (language) literacy as part of disciplinary pedagogy might well be more effective than separate English language courses" (see for example Jacobs, 2010; Volkwyn et al., 2010).

At this point is seems appropriate to identify a common conflation of "English language proficiency" and "academic literacy" (see also Boughey, 2002, 2003 and Jacobs, 2010). Whilst it is not the intention to engage in a debate about the ideologies of either of these terms, or the conflation thereof, it is helpful to clarify this issue to some degree. Boughey (2002) cites Gee (1990) when providing a definition for 'literacy': "the mastery of fluent control over a secondary discourse where the term 'secondary' is intended to refer to a discourse other than the 'home' or 'primary' discourse" (p. 296). 'Discourse' extends to more than simply using a language, to "thinking, feeling, believing, valuing, and of acting that can be used to identify oneself as a member of a socially meaningful group" (Boughey, 2002, p. 296 citing Gee, 1990). Street (e.g. 1998) expounds on the broadest notions of academic literacy, described as New Literacy Studies.

Although linguistic fluency in English is certainly necessary for the development of academic literacy (Boughey, 2003), according to this author, students' 'problems' should rather be perceived as stemming from their being outsiders to the academic culture or discourse of a University rather than the fact that their first language is not English (Boughey, 2002). This understanding that students may be struggling with "academic literacy" rather than with language issues per se, calls into question, says Boughey (2002), many of the interventions that have been put in place on the assumption that what students need is help improving their use of English. This is reflected by Jacobs (2010) who has identified that two common (mis)understandings amongst academics of engineering at one South African institution is that solving surface language problems such as syntax will improve academic performance, and that reading and writing skills, taught in a decontextualised manner are transferable to other disciplines of study.

Literacy lessons from an Access module. Parkinson et al. (2007, 2008) are very clear about the theoretical basis of the academic literacy modules designed to scaffold reading and writing for English Second Language learners in science access (specifically the foundation stream) at UKZN. These “Communication in Science modules” align with the ‘ideological’ model based on the work of Street and colleagues (e.g. Lea & Street, 1998, 2006) which understands literacy as a set of social practices, rather than a set of skills. These authors identify reading and writing within disciplines (academic literacy practices) as being the central processes through which students learn new subjects and extend their knowledge about new areas of study. The ideological orientation insists that the way a reader understands print is related to factors such as how individuals value the text, and how they perceive themselves in relation to it. There are therefore cultural and contextual components to reading and writing. This is in contrast to the stand-alone ‘autonomous model’ which has dominated literacy teaching in South African schools (Bloch, 2005, see below), and incorrectly assumes that all have equal access to the literacy practices and contextual knowledge required for its comprehension. Here, language is seen to be an ‘instrument of communication’ without an understanding of the way language is used to structure experience. This also assumes that “correct thoughts” already exist and have “only to be encoded into a grammatically correct form to be conveyed to others” (Boughey, 2002, p. 300).

The Communication in Science module thus recognises that academic literacy development involves acquiring the discourse of science, and that in order to be successful, students must be familiar with the different genre of each scientific discipline (Inglis, Kirkwood, Downs & Parkinson, 2007; Parkinson, 2000b; Parkinson et al., 2007, 2008). The module employs a genre-based approach to teaching that empowers students to read and write according to the genre conventions that are implicit in the sciences (Hyland, 2003 cited by Parkinson et al., 2007). This pedagogy makes explicit both the discourse and lexico-grammatical features of text and associated task; without the latter it is believed educationally disadvantaged students such as those in the Foundation Programme, would revert to more discursive practices that are more culturally familiar (Hyland cited by Parkinson et al., 2007, p. 445). It is recognised that for English Second Language learners in particular, access to the structural and linguistic features of text of a specific genre is valuable (Hyland, 2003).

Indeed, central to the teaching of the module is the understanding that the students, having come from disadvantaged schools, have had “limited exposure to academic texts and limited opportunities for extended writing" (Parkinson et al, 2007, p. 444). As briefly alluded to in Chapter 1, these authors acknowledge that these Access students' schooling has been "characterised by subtractive bilingualism" because the language of teaching changes from mother tongue to English early in the students' schooling (at the end of the Foundation phase when learners are about ten years of age, see Clarence-Fincham, 2000, Heugh, 1999, and Pretorius, 2002)[12]. This means that students' conceptual understanding, reading and writing skills have not been developed in their mother tongue before the change to English. Bloch (2006) cites Ramirez (1992) when describing the pedagogical consequences of this; research has indicated that the the development of skills required in an additional language for academic learnering take, on average, five years.

Furthermore, when the switch does happen, students simply do not have the English vocabulary to deal with the text books and academic tasks that they are faced with (see Clarence-Fincham, 2000, de Witt, Lessing & Dicker, 1998; Heugh, 1999, MacDonald (1990) cited by Dempster & Reddy, 2007). Thus instead of being able to transfer their Cognitive Academic Language Proficiency (CALP) into another language (English), they must develop their literacy skills and conceptual knowledge through the medium of an additional language they are learning at the same time (Parkinson et al., 2007; see also Pretorius, 2002 for a general description of issues around English Second Language (ESL) in South Africa).

The terms BICS and CALP are based on the work of Cummins (1984) (cited by Clarence-Fincham, 2000). Basic Interpersonal Communication Skills (BICS) are needed to conduct informal conversations in everyday contexts; CALP refers to the skills needed to successfully complete more academic and cognitively demanding tasks and is crucial to academic success. CALP is reported to take much longer to acquire than BICS in English Second Language learners (Cummins, 1984 cited by Clarence-Fincham, 2000), and is dependent on whether CALP has been developed in the first language. If CALP has not been developed in the first language, it is likely that considerable difficulty will be experienced with tasks requiring CALP in the second language. This has severe consequences for learners who become "despondent and unmotivated" and, in a negative cycle, the difficulties become even more severe (Clarence-Fincham, 2000). Yeld (2006)

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12. During the period of Bantu Education, learners were taught in their mother tongue throughout their primary schooling. After the 1976 riots, known as the "Soweto uprising", policy was changed to home language instruction for only the first four years of schooling (Heugh, 1999).

notes that Cummins's two conceptions of language proficiency, and the continua of contextual support and cognitive complexity along which they can be conceptualised, explicitly links language proficiency and cognitive theories of learning and knowing. Furthermore, it is noted that the degree of difficulty an individual encounters when faced with a particular task will be determined by his or her mastery of the linguistic tools necessary to complete that task.

Parkinson et al. (2007) explain that although foundation students have good Basic Interpersonal Communication Skills (BICS) in English, for the most part, their CALP is insufficiently developed in this language by the time they leave secondary school. Furthermore, the students arrive at University with far too little reading experience to be able to cope with the kinds of texts academic staff expect of them, largely because of their unfamiliarity with written English (which deters them from reading even more because it is laborious) and also because of the dearth of reading materials written in African languages (see also Pretorius & Matchet, 2004). In addition, notes Parkinson and colleagues (2007), English Second Language students in particular find scientific texts inaccessible because of characteristics such as nominalisation which makes text abstract and lexically dense. They also battle with vocabulary, not only technical words, but general academic words, and others considered "everyday" (p. 449). Because of these factors, their reading is very slow, and often assigned reading is not done at all (Parkinson et al., 2008).

It is important to note that the development of the Communication in Science modules was informed partly by research responding to mainstream lecturers' frustrations with the apparent inability of science faculty students to meet the demands of academic study, especially in terms of reading and writing (Jackson, Meyer & Parkinson, 2006). This study found a mismatch between science mainstream academic staff expectations of student reading and writing and mainstream pedagogy since staff did not see it as their task to induct students into these literacies (for example, the majority of reading is set from textbooks, and students gain very little experience reading research articles which would help considerably with the report writing they are expected to do). The module attempts to address such problems by explicitly accompanying teaching of a particular genre with the opportunities to practise in that particular mode; much emphasis is placed on the laboratory report since the study found that these tasks make up 60% of the written requirements in the Science Faculty at UKZN.

In acknowledging this in the development of the Communication in Science modules, Parkinson et al. (2007) foreground reading and comprehension as "being essential to writing; it is only when students read with comprehension that they can write effectively" (p. 446). Thus emphasis is placed on the scaffolding of reading and writing acquisition within the discipline of science.

Language literacy: A national problem for South Africa. The idea of reading and writing in English being fundamental to academic literacy in South Africa is articulated clearly by Yeld (2003). Seminal in the field of developing selection and placement tests for the Alternative Admissions Research Project (AARP) and the National Benchmark Tests Project (NBTP) in this country, Yeld provides a more traditional understanding of academic literacy than the broader notions called for by Boughey (e.g. 2002). Yeld (2003) describes academic literacy as the ability to:

> comprehend information presented in various modes; to paraphrase; to present information visually; to summarise; to describe (e.g. ideas, phenomena, processes, changes of state); to write expository prose (e.g. argument, comparison and contrast, classification, categorisation); to develop and signal own voice; to acknowledge sources; and to perform basic numerical manipulations. In demonstrating these abilities, (candidates) will be required: to construct and write summaries; to write expository prose in the form of a one-page essay in which they adopt, challenge, and/or support a position, drawing on the information provided in the texts; to construct and read graphs, flow-charts and diagrams; and to perform simple numerical manipulations within the context of the test's theme. (p. 27)

Yeld (2006) further demonstrates the relationship between academic literacy and language by describing the former as a student's capacity to engage successfully with the demands of academic study in the medium of instruction (the language) of a particular institution. Thus language proficiency is the "vehicle" of academic literacy (p. 23). Using this narrower understanding of academic literacy, Yeld (2003) reports that large percentages (as much as 55% in some institutions) of science students in South African higher institutions have language proficiency problems: reading, understanding, and interpreting text.

Indeed, low literacy (in particular with respect to reading ability) levels in South Africa are widely reported (see for example Mngoma & Sapa, 2011; Pretorius, 2002; Reuters-Sapa, 2007). Performance in the Progress in the International Reading Literacy Study (PIRLS), which measures reading literacy (in the language of tuition) amongst Grade 4 learners, was exceptionally poor with South Africa achieving the lowest score out of all 45 education systems. Learners who were tested in the African languages scored particularly low, with between 86% and 99% of learners failing to reach the lowest international benchmark (Howie et al., 2007).

In addition, the Systemic Evaluations done on Grade 3 literacy (and numeracy and life skills) in 2001 and 2007, and on Grade 6 in 2004 on the language of instruction, (and mathematics and natural science), revealed that, although marginally improved in 2007 from 2001, Grade 3 levels of reading performance were extremely low (36% in 2007) (DOE, 2009b). Fleisch (2008, p.7) states that it is clear that the average Foundation Phase learner in this country cannot cope with the demands of learning to read and write. Grade 6 results were even weaker than for Grade 3; in the 2004 assessment an average of 38% was achieved in the language of learning and teaching (usually English, see below).

More recently, the 2011 Annual National Assessment (ANA) found that the national average performance in literacy for grade 3 was 35% (Department of Basic Education, 2011). Performance for the grade 6 learners was equally poor, an average of 28% being achieved for language. In other words, South African school children, in the main, can’t read or write.

Much has also been written about the performance of South African learners in TIMSS (Trends in International Mathematics and Science Study, 1999 and 2003; South African learners attained the lowest average test scores in both mathematics and science in 2003 when compared to 50 other participating countries) (Howie, 2003; Howie & Plomp, 2002; Reddy, 2006b). Whilst it has been acknowledged that the extremely poor student performance in TIMSS cannot be attributed to one single cause, but a consequence of many factors acting together (Reddy, 2006b, p. 117), clear relationships have been observed between lower levels of performance and the fact that the first language of these students was not English (or Afrikaans, these being the languages of the TIMSS instruments) (Howie, 2003; Howie & Plomp, 2002). Indeed, most learners who wrote the test in English were not English home-language speakers (Dempster & Reddy, 2007; Zuma & Dempster, 2008). Certainly, as Howie and Plomp (2002) point out, poor performance on the open-ended

TIMSS items does point to apparent difficulties for Second Language Learners in the reading and comprehension of questions and in the articulation of written answers. However, it was noted by Reddy (2006b) that this issue of language is contingent on socio-economic factors, the teaching at different schools, as well as other inequalities in the schooling system. Dempster and Reddy (2007) reiterate this, pointing out that learners who use English as a second or third language for learning are generally socio-economically disadvantaged in the South African context.

Exploring the issue of language proficiency in TIMSS further, Dempster and Reddy (2007) investigated the readability of the multiple choice text-only test items. They found that learners from non-African schools[13], who had better English language proficiency did perform significantly better than learners from African schools and who were, in the majority, English Second (or Third) language speakers with lower levels of English proficiency.

This research explored sentence complexity and length and unfamiliarity of words as readability factors. Having found that many of the items had high levels of sentence complexity, and as such did not meet recommendations for maximum readability and comprehension, these items were deemed not suitable for learners with limited levels of English proficiency. It was concluded in this study however, that problems with readability overlie a lack of scientific knowledge, skills and reasoning in South African learners (see also Dempster & Zuma, 2010). As such recommendations suggested that interventions aimed at improving reading language proficiency (in particular reading and writing) need to be done in context of increased cognitive skill development including improvement of learners’ analytical and reasoning abilities.

Rollnick (2000) and Cleghorn and Rollnick (2002) reflect on the theoretical basis of learning in science; in particular the Vygotskian view that learning is mediated through the shared discourse of language, and the views of Gee (1997) who supported genre writing within a community of practice (both theorists were drawn on in the development of the CSA academic literacy modules). In acknowledging the inter-relatedness of language, context and activity, Rollnick and colleagues recognise the compounded challenge faced by students learning science in a second language – that they have to simultaneously learn the social practice of the (second) language, and its place in in science. To this end, Cleghorn

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[13] “African” schools here were identified as schools where almost all the teachers and learners belonged to African ethnic groups: “non-African” schools are heterogenous in terms of home language and ethnicities, but were originally established for White, Indian and Coloured students.

and Rollnick (2002) call for home language language instruction and/or bilingual programmes across all levels of education. Probyn (2006) and Heugh (1999, 2002) reflect this view, and Zuma and Dempster (2008) challenge the use of English over African languages for the purposes of assessment at secondary level in particular. Code switching (the use of a first (home) language and English interchangeably) may well contribute to better science knowledge construction (Rollnick, 2000; Cleghorn & Rollnick, 2002), but where schools name English as the official Language of Learning and Teaching (LoLT) and examinations are in English, this may have negative consequences for learners (see also Wildsmith-Cromarty & Gordon, 2009 who recognise that the terminology of science is not yet sufficiently developed in the home languages for teaching to occur primarily in these languages).

Dempster and Reddy (2007) have pointed these issues out in their analysis of TIMMS. As such, they hold that the learning of science "requires a learner to be proficient in the language of instruction as well as in the language of science" (that is the specialised vocabulary of science) (p. 907).

Probyn (2005) has indicated that there is strong resistance from learners and teachers to the call for extending the use of learners' home language as LoLT beyond the Foundation Phase of schooling (when it changes to English). In spite of the multilingual language polices in South Africa's education system, English remains the official LoLT for the majority of schools in this country, reflecting the growing international dominance of this language (Alexander & Bloch, 2004; Alexander, 2000, 2003; Cele, 2004), and a lack of government leadership (Alexander, 2003), ability and focus in this area of education (Probyn, 2005, 2006). Cleghorn and Rollnick (2002), and Heugh (2002) pointed out some time ago the failure of research on L1 and L2 development and bilingual education to be included into language-in-education policies and teacher development programmes, the latter pointing to difficulties experienced in "disentangling" languge use from its association with the historical manifestation of political ideology in educational policy (p. 3). Ten years on, there is still vigourous debate around this issue, and limited apparent practical moves towards revised policy.

In her 2005 study, Probyn found that although most of the oral communication in the class room took place in the learner' home language with teachers code switching to communicate the lesson content (because of learners' lack of English proficiency), the written language was English (notes and formal assessment). This practice was at odds with learners' and teachers' preferred classroom language, English being preferred by the majority because they perceived English to be the language of education and "access to the wider world" (p. 378) (see also Bloch, 2006; Morrow, 1999/ 2007c; Zuma & Dempster, 2008). This is particularly significant when one considers that the "power and status functions of language are most clearly marked in its printed form" (Alexander & Bloch, 2004, p. 1, see also Bloch, 2006).

Thus, although South African education policy promotes 'additive bilingualism' (the maintenance of home languages whilst access to, and acquisition of, additional languages is provided) (DOE, 1997b, see also the new Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2010), the reality is English is the official Language of Learning and Teaching (LoLT) for the majority of rural and township schools in this country (Probyn, 2006; Cleghorn & Rollnick, 2002). This is despite the fact that few of these learners have much opportunity to hear or speak English outside of schooling (Bloch, 2005; Nel & Müller, 2010; Pretorius, 2002; Probyn, 2006; Strauss, 1999). Furthermore, these learners have inadequate exposure to popular print media like magazines and newspapers, lack of books at home, and do not have access to libraries (Nel & Müller, 2010; Pretorius 2002; Strauss, 1999).

Most significant however is the influence of LoLT in the first three or four years of schooling when learners are being taught to read and write. As alluded to above, until the beginning of 2012, this instruction has been in learners' mother tongue (Bloch, 2005; Fleisch, 2008; Motshekga, 2011; Pretorius, 2002), with a rapid switch in Grade 4 being made to English (as the dominant LoLT). Many learners, lacking the basic skills in English, and very little additional reading support given after these initial three years, struggle to cope with the demands of the Grade 4 curriculum which sets in motion a deficit model of learning throughout subsequent years (Probyn, 2006). Teachers resort to code switching; this duality of home language for oral communication and the use of English for reading, writing and assessment makes it very difficult for English Second Language (ESL) learners to acquire the Cognitive Academic Language Proficiency (CALP) necessary for meaningful engagement with the school curriculum and beyond (Probyn, 2005).

Moreover, ineffective teaching of reading and writing has been identified by many (for example Bloch, 1997, 2005; Lenyai, 2011; Probyn, 2006, and Moore & Hart, 2007) as the root cause of South Africa's literacy woes, and the reason that learners cannot independently learn from reading. Probyn (2006) confirms that many of the schools attended by English Second Language learners place little emphasis on reading and writing, in part a consequence of the lack of textbooks. Rollnick (2000) and Cleghorn and Rollnick (2002) also describe the inaccessibility of school textbooks (in terms of readability and comprehension of text, and at times complete physical absence) (see also Slonimsky & Shalem, 2004). More fundamental than this however, is the recognition that the narrow skills-based approach to teaching reading and writing that has been traditionally used (not only in South Africa) is not as effective, as viewing literacy as a part of daily social and cultural practice (Bloch, 2005, 2006, 2009). This technical skills-based approach has placed emphasis on decoding rather than comprehension. In the context of the change in medium of instruction as described above, learners are unable to make the transition from decoding to comprehension. Pretorius (2002) describes this as a "move from a sparse L1 (first/home language) narrative text base to an extensive English expository text base" (p. 191). Learners continue to decode, but with little comprehension. MacDonald (2002, p. 129) refers to this reading with accurate pronunciation, but with little understanding as "bark(ing) at print". As Bloch (2005) admits, large numbers of children in South Africa do not learn to read and write, either in their mother- or any other-tongue. It is not surprising that this has had devastating consequences for academic performance.

Indeed, learning to read relies on learners having been apprenticed into such practices through exposure from a very early age (parents reading to children and reading for pleasure) (Bloch, 2005, 2006; Rose, 2007; Rose, Lui-Chivizhe, McKnight & Smith, 2003). During early childhood therefore reading is (or is not) established as a communicative activity. As Bloch (2005), explains, children who have come from text-poor communities where families have few opportunities (or reasons) to read and write in daily life, come to school without having developed important understandings about print, and the power and point of reading and writing. It is well recognised that one of the most revealing indicators of school performance is the amount of books at home (The School of Education and Development, UKZN, 2010).

Rose (2007) proposes that the expectation of the hidden curriculum of the junior phase of schooling, i.e. that all children are able to read independently by the end of the third year, automatically disadvantages those who have not had the benefit of an induction to reading by parents and junior primary teachers trained to build upon this early learning. The pattern for these children to continue to be disadvantaged has already been set, since each successive stage of reading development is based on the grounding of a preceding one (p. 44). Pretorius and Naudé (2002), from their research into township children, concur that these children are disadvantaged from the start with respect to this, and many other skills associated with literacy development (from poor fine motor development to problems with visual analysis) (although those proponents of whole language learning in South Africa would disagree with respect to the basis for deficiencies in literacy learning, see for example Bloch, 2005, 2006, 2009).

Pretorius (2002) also points out that most ESL learners come from oral cultures, rather than a “reading culture” (p. 190) (see also Boughey, 2008). Jansen (2012) extends this distance away from “book-literacy” by describing South African society on the whole as “visual and aural”, going as far as saying it is one that “despises books” (p. 7). (Halliday, e.g. 1993 has explored at length the alternative ways of construing the world attached to the differences between spoken and written discourses, between oral and text-based cultures).

Finally, Pretorius (2002) and Nel and Müller (2010) report that many teachers at secondary school level, even some teaching English as a subject, do not have good English literacy skills. Being apprenticed into a second language by teachers who themselves have a very poor knowledge and usage of the language is highly problematic; Nel and Müller (2010) refer to this “teacher talk” as a contamination factor in the use and learning of a second language (English in this context). These authors highlight how limited English language proficiency on the part of both teacher and learner, can obscure the “communication channels” for knowledge transfer and learning (p. 646). Furthermore, they see “language confusion” as a problem (for both teachers and learners) because of a mismatch between the language of Learning and Teaching (LoLT) and the social everyday language environment (also reported by Probyn, 2005). In the majority of cases studied by Nel and Müller (2010), English was the teachers’ preferred language of instruction even though English was not their preferred language in their own social environments or that of their learners (see Cleghorn & Rollnick, 2002 for more detailed discussion of the role of English in the development of individuals and society). Furthermore, teachers had a very inaccurate perception of their abilities to help ESL learners develop their English.

Language literacy in the tertiary education sector. Given these challenges, it is not surprising that a high proportion of students in South Africa enter tertiary education with inadequate reading and writing skills, having not sufficiently developed levels of Cognitive Academic Language Proficiency (CALP) as reported by Clarence-Fincham (2000) (see also Yeld, 2006). As Parkinson et al. (2008) point out, this situation makes South Africa unusual, because in other countries where English is not a first language, CALP has already been developed in students' own home languages. Nel and Müller (2010) note that the "transition which English Second Language students need to make when using English as the language of learning in higher education is a matter of great concern in the South African higher education sector" (p. 635). These sentiments reflect those of Pretorius (2002) who has for a while argued that the lack of reading ability is the "barrier" to learning in South Africa (p. 87).

Bohlmann and Pretorius (2002) have expounded on the ways in which students' mathematical performances are undermined by poor language skills, and in particular the extent to which a learner's reading ability (in the language of teaching) influences his or her ability to comprehend and do mathematics. Their study in a South African Mathematics Access module showed that whilst higher levels of reading ability (of mathematical texts in English) did not guarantee mathematical performance, poor reading (comprehension, not only decoding) ability did correlate with lower levels of mathematical performance, with weaker readers achieving comprehension levels of 50% or less (and who were thus reading at frustration levels) achieving very poor mathematics results. Nel, Dreyer and Kopper (2004) report similar findings in a first-year English for Professional Purposes module, with students experiencing problems across all aspects of reading (from vocabulary to reading comprehension and use of reading strategy). Pretorius (2002) too cites a number of studies done in South Africa that have pointed to decreases in functional literacy of applicants to tertiary study (that is levels of literacy below grade 8).

Slonimsky and Shalem (2004) refer to these problems related to reading and writing as deficiencies in working in, and creating, text-based realities. These authors are very clear about the need for students, particularly those considered under-prepared for university study, to learn to work with the properties of “text-based realities” if they are to become “full members of academic communities of practice” (p. 85). The properties referred to here are the depersonalised, systematised and bounded nature of text. With respect to these, the under-prepared student typically demonstrates a tendency for (amongst others) plagiarism, an inability to draw out (or make) arguments in text and carry out analysis thereof, or to write objectively. These issues were found to prevail in spite of the vastly changed education system in South Africa since 1994, and continue to abound, judging by recent reports (for example Hurst, 2010; Slonimsky & Shalem, 2010). Boughey (2008) suggests that students’ (especially those who are underprepared) engagement with university texts is based on their understandings of a context other than that of a university, and is indeed a complex issue requiring pedagogies that take cognisance of context and location.

Stephen, Welman and Jordaan (2004) cite English language proficiency as crucial to achieving academic success, and outline the factors affecting this proficiency. In their study at a South African tertiary institution, students’ English matriculation results are used as a measurement of English proficiency. The majority of students in this study had studied English as a second language at school, and although the matric English mark was not found to correlate well with student performance in the first year of tertiary studies, the results of an “English Second Language proficiency test” was found to be a better indicator of academic achievement. Students in this study perceived problems with comprehension of lectures delivered in English to be a particular obstacle to their performance.

On a more encouraging note, Miller and colleagues have shown that cognitive and linguistic under-preparedness in English Second Language learners may not necessarily be “a fixed immutable state but a transitory modifiable condition that can be reversed by appropriate intervention” (Miller, Bradbury & Acutt, 2001, p.152). This is in spite of initial investigations that showed that English First Language students consistently outperform those for whom English is a second language (Miller, Bradbury & Wessels, 1997). In their most recent work, Miller and Bradbury (2011) have extended their notion of under-preparedness beyond congnitive and linguistic issues to recognising that these are a reflection of a “systemic failure by the educational system to initiate these students into the world of academic study and its implicit rules of enquiry and knowledge construction" (p. 8).

A final note to this end, Hurst (2010) has shown that students' perceptions of their English language proficiency in higher education institutions where English is the medium of instruction, impacts negatively on their ability to cope with their studies, and that the discourse (in the narrowest sense of the term that extends to understanding of terminology) hampers understanding and thus performance. In terms of language, Hurst (2010) identifies a contradiction in South African policies (see Moore and Lewis, 2004). Whilst English provides access to the global economy (a national imperative), access to English Second Language speakers is imperative if issues of redress and equity are to be addressed. Thus producing graduates to operate in the global economy requires issues around English language proficiencies to be addressed.

The observations made above are born of the disempowering effect of the hegemony of the English language over the indigenous languages in South Africa, and beyond. This persists despite the National Language Policy for Higher Education (Department of Education, 2002a) which, in line with policy for schooling in this country, advocates multilingualism where-ever feasible. However, this policy does explicitly acknowledge the current position of English (and Afrikaans) as the dominant languages of instruction in higher education, and "believes that in the light of practical and other considerations it will be necessary to work within the confines of the status quo until such time as other South African languages have been developed to a level where they may be used in all higher education functions" (ibid, p.10) (see also Cele, 2004).

The language policy at UKZN (2006c) mirrors the national language policy, acknowledging that the benefits for students to become proficient in English, the dominant medium of academic communication, in government and institutions in South Africa, and in trade and industry internationally are clear.

Whilst there is growing body of research that is calling strongly for more active multilingualism (e.g. Alexander & Bloch, 2004; Alexander, 2003), and indeed at UKZN there is a strong move to offer as many courses as possible in bilingual (English and isiZulu) mode, it is not the intention of the current research to venture very far into this debate. Given the absence of short-term alternatives to the dominance of the English language in education, this research project adopts the position that the responses to the problems faced at tertiary level, and specifically within the science faculty of UKZN, must focus on supporting students to develop their proficiency in the current lingua franca, English.

A response to language literacy problems. At UKZN, the inability on the part of undergraduate teaching to fulfil the needs of English Second Language (ESL) students of science has been recognised by some for a long time (e.g. Inglis, 1992). Somewhat more recently Hart, at a workshop titled "Learning to read. Reading to learn" held at UKZN, expounded on his own observations of this issue at this institution (M. Hart, personal communication, September 13, 2006). To date, it appears that problems related to learning science in a second language remain largely unattended to in mainstream at this university.

Certainly in the research reported here, performance in school English has been shown repeatedly to have more influence over mainstream accomplishment in the core module investigated than any other factor, including the successful completion of the "foundation package". Whilst ex-Foundation Programme students are certainly advantaged with respect to the continuous assessment and practical components of the module, they remain challenged by the same factor as any other student, irrespective of year of matriculation, ethnicity or access route to mainstream. It is evident that their English, most likely their CALP in this, their second language, continues to hamper progress in mainstream in spite of what they have gained in Access.

Indeed, as Parkinson et al. (2008) report, although improved language literacy levels (as indicated by tests designed to test English proficiency) were recorded for most Access students completing the Science Communication module in 2006, the performance of the weakest third of students was still below that of regular Faculty entrants in terms of both reading and writing, and would, it was considered, benefit from further academic (language) literacy modules. This is despite the weakest group having made the biggest improvement overall. In this study by Parkinson and colleagues, improvement of text interpretation indicated reading skills had been developed in most students, although not to an acceptable level in this weakest third of the students. All students improved their performance in writing tasks based on extracting and interpreting information in provided texts, but only to an acceptable level in the strongest third of the student group. This study also showed that the strongest third of the group improved more in writing than reading, suggesting that once a certain level of reading proficiency is reached, students respond well to writing support.

Acknowledging the theoretical framework of the academic literacy modules developed for English Second Language learners in the CSA at UKZN, the research findings describing the literacy problems experienced by ESL learners in South Africa, and the results of this study, it appears prudent to suggest that the mainstream curriculum needs to explicitly include an academic (language) literacy component. Specifically, addressing the fundamentals of reading and writing for **all** mainstream BIOL 101 students whose levels of school English performance suggests their English literacy is weak is one possible response to the deficiencies revealed in the module. It is acknowledged that this assumes school English performance provides some indication of literacy in English. Given the iterative nature of what has been presented, and the simple fact that English is the medium of teaching and learning at UKZN[14], perhaps this assumption can be made with some measure of confidence. Certainly though, such a responsiveness is more appropriate in the context of current conversations around access to science in South Africa, and the national educational literacy “crisis” (Pretorius, 2002) than raised “English proficiency” entry requirements (see Stephen, Welman & Jordaan, 2004).

Indeed, integrated skills model foundation programmes have recognised that difficulties with ESL student’s English cannot be fixed by autonomous modules; attempting to fix surface forms of language such as grammar and sentence construction are not adequate in dealing with “deep seated consequences of DET school education” (Kloot et al., 2008, p. 804). This view reflects the research by Jacobs (2010) (see also Jacobs & Jacobs, 2002) who advocates a ‘collaborative pedagogy’ based on the academic socialisation model of academic (language) literacy teaching (as described by New Literacy Studies, for example Street, 1998 mentioned earlier). This approach suggests that language literacy practitioners work side by side with mainstream discipline lecturers to teach in ways that embed reading and writing within the ways that particular academic disciplines use language in practice. Thus it aims “to enculturate students into conventions of disciplinary discourses and genres, with a focus on reading and writing texts as a conduit for meaning” (p. 2).

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[14] Acknowledgement at this point must also be made of the complex debate around the African renaissance, the intellectualisation of African languages, and “the long road’ ahead for this to be achieved, particularly at higher levels of learning (Alexander, 2003, p. 29). Entering this debate is beyond the scope of the current research.

Jacobs and Jacobs (2002) refer to the “strong approach model of integration” for foundation programmes as being favourable, where language learning (as a component of academic literacy) is situated within the context of the chosen discipline of study. Here, there is a crossing of boundaries between the discipline and academic literacy; the development of a common understanding among the different curriculum development parties (in well designed “transaction spaces”) and a tendency towards transdisciplinarity.

Nel and Müller (2010) also call for provision to be made for first-year students (teachers in training) to be able to improve their own cognitive academic language skills to better teach ESL learners using English as the medium for teaching and learning. Nel, Dreyer and Klopper (2004) emphasise the need for reading support in particular, whilst Rollnick and colleagues (see review in Rollnick, 2000) have focussed on the integration of writing skills into the teaching of science.

Boughey (2002) calls for “literacy across the curriculum”, and stresses the need to develop language within the mainstream curriculum that “empowers” rather than disciplines as does the received tradition of English language teaching that focuses on grammar teaching. She also notes language teaching can have important influences over the production of in-house teaching and learning materials (Boughey, 2002).

On the basis of their findings, Bohlmann and Pretorius (2002) call for reading tests, not as gate-keeping tools, but to identify students who would benefit from improved reading skills before attempting mainstream mathematical courses, and call for the development of such modules. This approach would be appropriate in the context of the BIOL 101 module in this study, given that some students’ levels of school English are sufficiently high for this factor to not impact negatively on their performance.

Institutional responsiveness and epistemic access. The different mainstream responses discussed above (at the levels of curriculum and pedagogy) offer opportunities for students to achieve epistemic access as also described by Holtman, Marshall and Linder (2004). However different levels of response are contingent on each other and on institutional discourses and transformation (Moll, 2004). In addition, as Moore and Lewis (2004) point out, such responsiveness requires expertise in academic development, which is often absent in the mainstream academic community. Furthermore, mainstream academics are not accustomed to an integrated and coordinated management approach to their teaching (ibid.). In addition, lecturers may be inclined to “blame” students for failure (see Fraser & Killen, 2005), taking little responsibility themselves. This is recognised internationally:

McInnes (2001) acknowledges that one of the considerable obstacles to major changes in curriculum design and delivery that are required to meet the diverse needs of a heterogenous student body, are the underlying tensions inherent in the core values of academics (p. 113). This may be particularly so as underprepared students place heavier pressure on teaching resources and where there is a perception that academic standards are compromised by including these students (see Jansen, 2010 for a view on the consequences of such on broader epistemic issues).

As Kloot, Case and Marshall (2008) acknowledge, whilst (marginalised) traditional foundation programmes allow for innovation, this is considerably more difficult to achieve in mainstream curricula because of the “vested power interests” in these offerings (p. 813) (see also Kloot, 2009). Yet, as Marshall (2010) suggests, mainstream responsiveness of this nature, that is, one with a socio-cultural perspective on learning, obviously requires buy-in from the mainstream practitioners of science themselves (given that students are being inducted into their disciplines), and not only those whose primary commitment is academic development. To this end, it would seem apparent that language literacy teaching also can not take place through add-on modules taught separately by literacy practitioners, who are often itinerant and marginalized (see Jacobs, 2010).

This need for institutional responsiveness was acknowledged at the 2010 ASSAf forum (see above) and by many who have been involved in the conversations around mainstream responsiveness (e.g. Jacobs, 2010; Moll, 2004). Resistance to curriculum responsiveness has been reported, especially where research is valued over teaching and learning (see Kloot, 2009), where there is a perception that this will lead to falling standards or that there will be negative financial implications for institutions (Marshall, 2010). As Morrow (2003/2009a) asserts, changing a curriculum is far from easy, and is likely to raise anxiety and conflict with parties failing to reach agreement about what should be done. This is partly because any current curriculum is comfortable for those who teach it. Indeed, it was the absence of responsiveness at the institutional level that led Parkinson et al. (2007) to opt for a separate (note, not autonomous in the academic literacy sense described earlier) Science Communication module for the Foundation Programme at UKZN as, at the time of its development there were concerns about responsiveness at the pedagogical level not being realised without wider support.

However, where there is institutional responsiveness, success stories have been reported such as in the high impact modules mentioned earlier (e.g. Englebrecht, 2010). In response to the concerns raised, counter responses point out the international trend towards similar research-based curricula reforms that focus on how learning best occurs, and which have benefited all students not only those deemed disadvantaged (Marshall, 2010). This author also points out that the long term cost to government and university alike, of student failure outweighs the short term financial costs of implementing reform. Indeed, Probyn (2006) has identified the implications for access and equity if the issues of language in teaching and learning are not addressed.

Moreover, universities have a responsibility to find ways of enabling epistemic access for students who have the potential to succeed, but whose secondary schooling has left them unprepared for the challenges of tertiary study (Morrow, 2003/2009a, 2007d; Yeld, 2003). Failure to do so will lead either to unacceptably high failure rates, or to lowered standards as institutions "attempt to avoid the inevitable consequences of educational under-preparedness in the absence of appropriate educational provision, by passing students whose performance is not adequate" (Yeld, 2003).

Morrow (1994/2009b) makes the seminal distinction between formal and epistemic access, the former depending on admission rules, student finances and the like, the latter being about access to the processes of knowledge construction. Whilst formal access is no doubt important in a country with an exclusionary history, epistemic access (central to which is teaching as the practice of "organising systematic learning") says Morrow (1999/2007c, p. 63) aptly is "what the game is about" (Morrow, 2007d, p. 2). Moreover, epistemic access is something students themselves have to achieve, formal access can be granted without much effort on the part of the student (one cannot talk of entitlement to epistemic access) (Morrow, 1994/2009b). Achieving epistemic access to a particular discipline links (the student) "into a trans-cultural community, and relates him or her to the ideals of human emancipation" (ibid., p. 84). Boughey (2005) reports that issues of epistemology and epistemic access are under-researched in this country.

To reiterate the words of Pikethly and Prosser (2001, p. 186) whose work is based on that of Tinto (1987) (a pioneer in the field of university student persistence) (see also Tinto, 1982): "with specific knowledge of the experience of its own students, the concerned university will seek to alleviate issues over which it has control".

Facilitating students to achieve epistemic access in the ways described will contribute towards their learning how to successfully participate in the academic practice of science.

CHAPTER 8

Attempt to Answer Question 2 of Objective 3: Factors Influencing Performance of Foundation Programme Students

Rationale and Method

Question 2: What factors are most important in determining the performance of Foundation students in their access year?

The research presented in the previous three chapters has shown that the Foundation Programme has indeed been an effective mechanism for enabling mainstream epistemic access to students who have succeeded in their Foundation year. Having established this success, it seemed useful to identify and explore possible opportunities for remediation in the existing Programme that could contribute to maximising student potential, and their preparedness for successive Biology modules.

Indeed, identifying the factors that contribute to student performance in their access year presents an opportunity to find ways of increasing the success rate of the Foundation Programme. As has been pointed out in Chapter 1, the numbers of students proceeding from the Programme are limited. Furthermore, it is an opportunity to examine the selection processes at a time when the large majority of students who apply to the Foundation Programme are turned away because they do not meet the criteria for selection.

It has also been established in Chapters 6 and 7 that language literacy is an important limiting factor on Foundation student performance in mainstream, as it is for the majority of students in BIOL 101, the high-impact first-year module investigated. Gaining insight into the effect of this, and other, factors on the academic performance of the Foundation Programme students in their access year, thus also has potential from a curriculum development point of view.

Other Factors affecting Student Performance – Evidence from South Africa and Abroad

Prior academic performance. Internationally, there is much research to show a positive relationship between previous academic performance and performance at university (for example, Burton & Dowling, 2005; Busato, Prins, Elshout & Hamaker, 2000; McKenzie, Gow & Schweitzer, 2004; Smith & Schumacher, 2005; Zeegers, 2004).

As McKenzie and Schweitzer (2001) report however, these relationships are often not clear cut as the success of some individuals or groups of students (such as those who are mature in age) cannot necessarily be predicted upon the basis of school grades. In the context of an equity and access programme in Australia (one that resembles a typical in-house, in-reach South African access programme, see Rollnick, 2006), Levy and Murray (2005) indicate that school leaving academic results were not a reliable indicator of subsequent student performance. Notably the students entering this programme were considered to belong to a designated “underrepresented group” in tertiary education and would not have qualified for entry into a mainstream programme on the basis of their secondary school results.

Indeed, as has already been pointed out, there are conflicting reports on the predictive validity of the South African matric results, and although the preceding chapters have indicated that the Senior Certificate matric score has been a good indicator of future academic performance for White students in the past, and there is evidence that the NSC matric score is a good indicator for all ethnic groups in the mainstream module investigated, the predictive reliability of the matric score for selection into the Foundation Programme, is unknown at this point.

In terms of selection into South African access programmes, most institutions have implemented alternative selection methods for educationally disadvantaged students; these are designed to give an indication of potential to succeed in further maths and science studies (Altink, 1987; 1991; Haeck, Yeld, Conradie, Robertson, & Shall, 1997; Rutherford & Watson, 1990; Zaaiman, 1998; Zaaiman, van der Flier & Thijs, 2001). Methods have included aptitude tests, English and mathematics proficiency tests, learning potential tests, interviews and the assessment of study habits and motivation (Zaaiman, 1998). More recently, Van der Flier et al. (2003) have shown that aptitude-type selection tests particular to their specific university context have been found to have value in predicting academic performance.

The National Benchmark Tests Project (NBTP) has been established to assess the levels of academic and quantitative literacy and maths proficiency of students entering higher education, and to provide benchmarks to inform admissions and placement, and curriculum responsiveness (Griesel, 2006; HESA, n.d.). An underlying assumption of the NBTP is that the South African school leaving results prior to the implementation of the

National Senior Certificate were not an accurate reflection of student potential; in addition the National Senior Certificate has been undergoing benchmarking in recent years (e.g. Umalusi, 2009), and reports about its predictive ability are varied. The NBTP also assumes that students require particular levels of knowledge and skill in order to gain epistemic access to the disciplines they are to study. If higher education is to respond to students' needs, it needs to understand the nature of under-preparedness of these students (Griesel, 2006; Yeld, 2003).

The NBTP has been built on two other projects, the Alternative Admissions Research Project (AARP) and the Assessment Project (TELP II) (now known as the Standardised Assessment Tests for Access and Placement (SATAP) Project) (Yeld, 2006). Although UKZN has been involved in the piloting of the NBTP tests they have not been used for admissions or placement into the Access Programmes (and indeed there is some disagreement about their value in informing admissions decisions, see University of Witwatersrand (WITS), 2010). However, as has been briefly mentioned in Chapter 1, the SATAP English for Academic Purposes Test has been used in the past for selection, and in recent years for placement into the different academic literacy modules.

Performance in in-house maths and science selection tests, specific to UKZN, has been used in conjunction with students' matric scores in a composite "Selection Total" as a means of selection into the Foundation Programmes. This selection score has been found in the past to have better value than the Senior Certificate matric score alone in selecting students who succeed (Grussendorff et al., 2004, p.270). The tests and the student body have changed considerably since this study was conducted. Furthermore, given the cost of running the selection tests, questions have been asked about their predictive value, and the alternative possibility of using school maths and science admission point scores as predictive indicators (Centre for Science Access, 2010). Thus, building on, and being informed by, other work into selection into access programmes that has been already been explored in previous chapters, the Foundation Programme mechanism for selection will be investigated.

Cognitive, personal and motivational factors. In addition to previous academic achievement, the other two most frequently reported factors found to be pertinent to academic success are preferred learning and attributional styles and self-efficacy (Burton & Dowling, 2005; McKenzie & Schweitzer, 2001). In contrast to the latter, the former authors found self-efficacy (defined as a student's "optimistic belief in their ability to cope with stress in a variety of challenging situations", p. 73) to have little significant effect on academic performance. This was also found to be so by Zeegers (2004). The components of a student's "learning profile" that were shown by Burton and Dowling (2005) to have significant impact on academic performance were personality traits, in particular, extroversion. In contrast, Busato et al. (2000) and Van der Zee et al., (2002) found that conscientiousness was the best predictor while McKenzie et al., (2004) found that introverted, agreeable students outperformed others. In one South African study exploring the effect of learning strategies on student success, Hendrich & Schepers (2004) found that students' attitudes to tertiary study, and motivation levels (here an indication of their willingness to work hard and be self-disciplined) played a significantly positive role in academic achievement. Learning approach (as opposed to learning style) has also been explored by Rollnick et al. (2007) who found that while access students commonly believed it more important to understand academic work rather than memorise, they were also unsure about whether the hard work was worth the effort as they performed poorly. These authors suggest that academic development practitioners may be overcompensating for these students' previous experience of surface learning to their detriment, as this approach to learning can indeed be strategic. In addition, perception of learning environment has been found by Lizzio, Wilson and Simons (2002) to be a stronger predictor of learning outcomes than prior academic performance, with negative perceptions of workload and assessment practices resulting in a surface approach to learning. What is apparent is that the results of these studies were particularly pertinent to their immediate research circumstances.

Other researchers have a somewhat different understanding of self-efficacy. Self-efficacy, as described by McInerney, Roche, McInerney and Marsh (1997) and McInerney and Sinclair (1991), is only one of three components of student motivation, otherwise referred to by these authors as personal investment. McInerney and Sinclair (1991) explain that a student's interpretation of a classroom situation will be determined by their sense of self (their perceptions, beliefs and feelings related to who they are, i.e. their self-efficacy), their awareness of the possibilities for action in the situation (behavioural alternatives), and thirdly, the personal incentives of behaviour (goals) in a given situation. Two of these three components formed the basis of the Inventory of School Motivation (ISM) devised by Braskamp and Maehr (1983) (cited by McInerney & Sinclair, 1991): the “sense of self” and “personal incentives/ motivational goals” dimensions. Original work by McInerney and colleagues included measures of both, and whilst traditional models of school motivation have distinguished extrinsic motivation from intrinsic motivation, more recent models have concentrated on the latter only: students’ goal orientations (Yeung & Yeung, 2001). Indeed, the influence of student motivation on educational outcomes has been studied extensively by many and is a major field of study in educational research (McInerney & Ali, 2006).

Ali and McInerney (2005) have shown that the ISM **is** effective in explaining variation in academic performance, and this has been demonstrated in a South African context (Watkins, McInerney, Akande & Lee, 2003). By all accounts, according to the literature, the motivating properties of the goals that students bring to their learning environment appear to be paramount in determining performance. Indeed as Covington (2000) points out: “(b)ased on the accumulating research it is concluded that the quality of student learning as well as the will to continue learning depends closely on an interaction between the kinds of social and academic goals students bring to the classroom, the motivating properties of these goals and prevailing classroom reward structures (p.171)”. The issue of motivation (or personal investment) is no small matter. Complex interactions exist between an individual’s internal motivation, and the external forces in a student’s social environment that may facilitate or inhibit the translation of these internal motivations into positive academic behaviour (see McInerney, Dowson, & Yeung, 2005).

Non-academic factors. Fraser and Killen (2003) point out that rather than focusing on academic pre-enrollment predictors of success it is more useful to concentrate on non-intellective factors that come into play after starting at university. Non-academic, demographic factors that have been found to affect student performance include age, gender, ethnicity, places in residence, and psychosocial predictors such as socio-economic status and financial situation, employment responsibilities and status as a first-generation student. For example, Ma (2005) expounds on the relationship between age, race and socio-economic status (including family size), and achievement in mathematics. Ma describes in this study how, whilst young White and Asian male students showed the highest growth rate in mathematics achievement, older males in these ethnic groups who had lower socio-economic status, fared the worst of any student group.

Tinto (1998) cites social integration outside the classroom (in residences) as having a beneficial role in the classroom which improves persistence at university. This, says Tinto (1998) provides argument for the adoption of a community model of academic organisation that would promote shared, connected learning. More recently, a study by Newman-Ford, Lloyd and Thomas (2009) showed that a place in residence emerged as having a significant effect on Scottish student academic achievement. This factor was also shown to be correlated with attendance at University. In addition, Holdsworth (2006), and Patiniotis and Holdsworth (2005) argue that residential status is a key demarcating factor in how successfully students feel they adapt to being at university.

By contrast, Cheesman, Simpson and Wint (2006) found in a study located in the Caribbean that students living in the university residences do not perform as well as those students who commute. These authors also found that those students who applied for financial assistance outperformed those that did not, whilst recognising that many poor students are averse to seeking financial assistance. Indeed, Tinto (2005) names financial support as an important condition for student success, and Humphrey (2006) highlights the impact of working part-time on the performance of financially disadvantaged students, calling for the introduction of non-repayable maintenance grants for these needy students. In contrast, McKenzie and Schweitzer (2001) found no significant differences between levels of financial difficulty (classified by these authors as a psychosocial factor) and student performance. As Harrison (2006) reports, the role that financial circumstances plays in student retention has been found to vary considerably.

A literature search for South African studies investigating the effect of having a place in a university residence and financial assistance on student academic performance revealed surprisingly little work conducted in this field. However, related to these factors, Zaaiman (1998) has shown that parental educational and occupational levels, especially those of the mother, do have significant positive effects on student achievement. Furthermore, high school quality, associated with high socio-economic status positively influences academic achievement. Zaaiman (1998) cites Riehl (1994) who found that first generation students had lower academic aspirations and did not achieve as well as those who came from families whose parents had higher education qualifications. Furthermore, research has shown that students who come from high socio-economic status families are stimulated to be more self-motivated and have high levels of intellectual curiosity as a consequence of the more autonomous, unsupervised positions held by their parents.

Grayson (1997) also reports that first-generation students face a number of challenges that those students who have at least one parent with a university education ("traditional students") do not – such as lower levels of academic and social integration, and less positive out-of-class experiences. This author found, in a Canadian context, that first-generation students showed lower levels of academic and social involvement in university activities than traditional students but this did not necessarily disadvantage them as some of these activities appeared to actually lower academic performance (namely involvement in clubs and attendance of non-required activities such as attending guest lectures etc.).

Zaaiman (1998) also reports that studies have shown that in lower socio-economic groups, there is more gender stereotyping, with low income families tending to support the educational aspirations of boys more than girls.

Methods for Data Collection

As was the case for the research on performance in the first-year Biology module, permission to conduct this component of the study, and have access to the relevant data stored on the University electronic systems relating to Foundation students' school results, demographic information and university results was requested, and granted, from the relevant authorities (Appendices I-K). Similarly, ethical clearance for the research was approved in 2009, and updated for the purposes of doctoral study in 2012 (Appendix L).

The outcome variables for this part of research, namely the performance of the 2008 Foundation student cohort in each of the five foundation modules, their average mark across these modules, and their pass or exclude status at the end of the foundation year was accessed via the Student Management System (SMS), Examination of Results Schedules (ERS), and from CSA examination results spreadsheets. By the time this research had progressed to the point of analysing 2008 data, final Foundation results were available for the 2009 cohort although the students themselves had left the CSA (see below). In the interests of expanding the developing grounded theory, this research was thus extended to include the 2009 foundation cohort. Details pertaining to the explanatory variable data for the 2008 and 2009 analyses are outlined below.

For both the 2008 and 2009 cohorts, both the 099 and 199 Foundation streams of students were included in the analysis, a total of 79 and 88 students respectively. The 099 students are accepted by UKZN having not achieved the minimum statutory requirement for entry into mainstream study (no endorsement), whereas the 199 students have received their matriculation with endorsement.

Ethical considerations were adhered to by ensuring that once data collation and cross-checking were complete, student numbers, and therefore all reference to personal information pertaining to a particular student, were erased from the data sets, ensuring anonymity (Appendix L).

Biographical data. By referring to records on the Student Management System (SMS), the gender and home language of each Foundation student was identified.

School history data. The name of the school attended by each Foundation student was made available by the Faculty Officer for Science Access. By referring to the website of the Department of Education (2009c), each school was assigned to the correct quintile, where 1 indicates the most under-resourced of schools and 5 indicates the most resourced (see Chapter 1).

Data pertaining to total admission point scores (APS) (otherwise known as “matric score”) for the 2008 cohort of Foundation students were collected from the SMS, and cross checked with data from the ERS. Where inconsistencies were found, this score was manually recalculated. As has already been outlined, an explanation for the calculation of APS for the Senior Certificate is provided in Appendix A.

Of the 88 Foundation students in 2009, 35 (40%) had written the Senior Certificate and 53 had completed their schooling receiving an NSC. The total APS was calculated for the NSC students using the criteria outlined in Appendix B. In a similar manner to compiling the data set for performance in the first-year Biology module, the scores for those that had written the Senior Certificate required some adjustment to ensure parity across the 2007 (pre-NSC) and 2008 school cohorts. Admission point scores were normalised accordingly for the 35 Senior Certificate students in the 2009 Foundation cohort, and a "matric score equivalent" was calculated by adding their converted subject scores using Appendix C which provides details of the normalisation process. In addition, a matric score was calculated for the 35 Senior Certificate students using Appendix A.

Admission point scores for individual school subjects, specifically English, maths, physical science and biology (life sciences in 2009) were also recorded from the ERS. Similarly for the 2009 data set, to provide parity across the two schooling system, an "APS equivalent" score was calculated for the 35 Senior Certificate students. For example, a 2009 Foundation student who achieved a higher grade B in the Senior Certificate in 2007 would have been awarded 7 points had they been in the 2008 Foundation cohort; being in the 2009 Foundation cohort they received 6 normalised points. Similarly, a 2007 matriculant in the 2009 Foundation student body achieving a standard grade D was given a score of 2.5; if completing the foundation year in 2008 this student would have been awarded 3 admission points. Thus for the 2009 cohort, APS is referred to as "APS equivalent".

For the 2008 cohort, information pertaining to whether students had completed their subjects on Higher or Standard Grade was also recorded. For both 2008 and 2009 Foundation cohorts it was noted whether students had taken English as a first or second language in their final year at school.

Where inconsistencies in data across sources were found to exist, or in cases where data were missing, relevant information was manually extracted from the administrative student files with the assistance of the Faculty Officer for Science Access.

Selection tests and selection model scores. As mentioned, to gain entry to the Foundation streams of the CSA, potential students are required to write in-house maths and science selection tests. Selection tests are aptitude-style, aimed at testing subject-related problem-solving skills and insight with as little content knowledge as possible. Selection tests are written by potential students from October the year before admission through to the following January. Usually the last set of selection tests are written no later than three weeks before the start of the new academic year.

Data for the maths and science selection tests, and students' selection model scores were made available for this research by the Faculty Officer for Science Access. The Selection Model Score is a composite score used to guide selection of potential Foundation students; it is generated by the CSA selection committee. The following formula was used to select both 2008 and 2009 Foundation cohorts:

24.32 + 0.28 ("M score") + 0.22 (maths selection test score) + 0.07 (science selection test score), where "M score" is defined by matric maths and science admission point scores only. This "M" score takes the form of a fraction, expressed as a percentage, in which the numerator of the fraction represents a student's APS points for maths and science and the denominator of the fraction represents the maximum possible score achieved for the subjects taken. For example, if a 2009 student did only one science subject in addition to mathematics, their summed APS would be divided by 16, 8 being the maximum APS possible in 2009. Where the selection tests are costly to run, obviously minimal costs are incurred generating an "M score".

Figure 30 provides the specific values for each criterion that are referred to when the decision to offer to a potential student a place in the Programme is taken (by kind permission the Faculty Officer for Science Access, November 5, 2010).

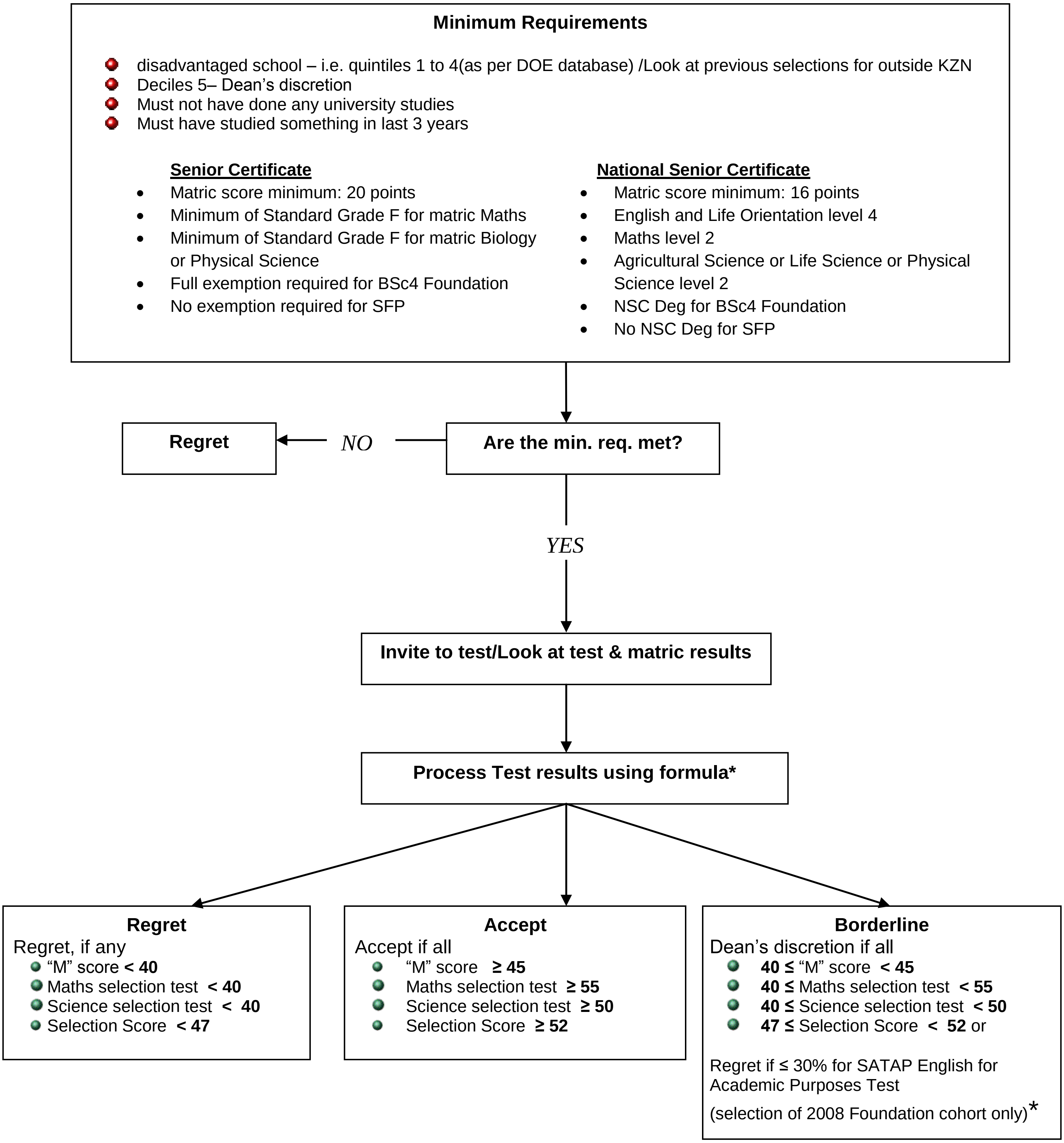

Figure 30. Flow chart used by CSA Selection Office to show suggested minimum criteria for selection into the Foundation Programme (by kind permission Faculty Officer for Science Access).

*Note** For selection of the 2008 Foundation cohort, this criterion was overridden by the Selection Committee in particular cases where prospective students were felt to have potential in spite of not achieving this sub-minimum (Centre for Science Access, 2008).

SATAP test scores. Although used in the past for selection purposes, the Standardised Assessment Test for Access and Placement Test (SATAP) (English for Academic Purposes) was not a stringently applied criterion in the selection of the 2008 Foundation cohort (see Centre for Science Access, 2008). The 2009 Foundation and Augmented students wrote this SATAP English test after registering for the programmes for which they had been selected; i.e. the test was not used at all in the selection of the 2009 cohort. The results of this test for the 2008 and 2009 cohorts were available before the start of the academic year and were used to stream students into the academic literacy modules. This practice continues in the CSA. Those students found to have lower English language proficiency, as indicated by the SATAP English test are required to register for two modules of Communication in Science. Those students found to be initially more competent in English are streamed into Scientific Writing and Reporting modules. Scores for this test were made available for this research by the CSA academic literacy staff who administered the tests, although this data was also available on selection spreadsheets administered by the CSA Selection Office. Interestingly, this is the same test used by Parkinson et al. (2008) to examine the effectiveness of the Science Communication modules discussed in Chapter 7.

Socio-economic and psychosocial factors affecting performance. In November, 2008, prior to the formal onset of research which received ethical clearance at the end of 2009, but anticipating some components of the study, data pertaining to Foundation students’ accommodation and travel arrangements, and the extent of their financial support during their access year, were collected as part of the routine module evaluations that are run at the end of each academic year (Appendix M, with the items pertaining to the general module evaluation removed). The main reason for collecting these data at this time was that, at the end of the year, the 2008 Foundation student body would disperse, and it was rightly anticipated that many of the students would be impossible to trace in the new year as they would not continue their university studies. All 79 Foundation Biology students completed the module evaluation. These evaluations, as is routine, sought feedback from the students with respect to their experiences of the Foundation Biology curriculum, learning materials, teaching and support, and requested from them any constructive feedback on what aspects the module could improve for the benefit of future generations of students. In context of the explanation on the purposes of module evaluations given to students, it did not seem inappropriate that they were asked what other aspects of the year they had struggled with (such as living off campus, traveling long hours to University or experiencing financial problems). These questions, although asked within the context of the Biology module, are pertinent to all foundation modules.

Similarly, within the context of a formal module evaluation, it was deemed appropriate that students were asked how they had felt about the Foundation Biology module and what had motivated them. At the time this information was collected there was uncertainty as to whether the data would be used for research purposes or not. Despite this, every attempt was made to ensure that the set of questions to gauge their motivational goals with respect to the biology module was valid and reliable (see below). This questionnaire was adapted from the inventories given in Ali and McInerney (2005) and McInerney and Ali (2006), and relate to the four perceived goals of behaviour. The theoretical framework upon which these questions were based has been alluded to earlier, and is described in greater detail below.

The questions concerning financial support were devised with consultation with the Centre for Science Access (CSA) counselling staff who are responsible for administering financial packages to students who qualify for these, in liaison with the University Financial Aid officers.

The questionnaire (as part of the module evaluation) was administered to students in their normal, timetabled biology practical period in the last week of the 2008 academic year. As there were two foundation biology classes in 2008, each session began with a standardised, verbal explanation of the purpose of the evaluation. It was explained that research conducted in the CSA was ongoing and intended to inform future strategies aimed to provide Foundation students, such as them, the best possible chance at succeeding in their studies. The students’ attention was drawn to the fact that although they would not themselves benefit from their own input, they had already benefited from the contributions of past students as the module’s curriculum allows for both reflection and responsiveness.

Students were informed that routine evaluations such as this sought to explore the factors that affect their academic performance, and in response, to find possible ways of remediating problems with the curriculum from year to year. It was informally acknowledged (verbally) that factors other than their innate academic ability might be affecting their performance. Not only might there be issues inherent to the module (for example teaching staff) that might influence their performance, but other factors concerning their personal academic environments such as how far they travel to University every day, whether they have places in Residence, or whether they have financial aid. In addition a brief explanation of motivation was given and it was explained that different individuals are motivated by different factors.

It was made very clear to the students that their responses were voluntary, would in no way influence their final Foundation Biology mark, and were completely confidential. (The researcher went as far as to say to the students that she would not have the time to analyse the survey results before their final exams were marked – an apparently unnecessary comment to make, but one that appeared to add to their willingness to complete the questionnaire and sign the agreement form attached to it). By giving as full an explanation as appropriate (not too detailed, but also sufficiently informative for the students to understand what they were a part of), it was hoped that students felt at ease. Apparently, all students felt comfortable with the process as none voiced dissent when offered the opportunity to ask questions, seek clarity, or comment. Not one of the students present refused to sign the form and complete the questionnaire.

Due to the comprehensive verbal explanation that was given (as is routine in all Foundation Biology module evaluations), the simple statement seeking informed consent as given in Appendix M was deemed sufficient. The issue of anonymity was not covered in the explanation as students were requested to provide their student numbers (for the purposes of collating data). Once full data collation was complete, these student numbers were removed from the data set. Thus, once collated and cross-checked, the data was entirely anonymous.

Thus, as described above, ethical considerations were adhered to by ensuring all participants were fully informed of the purpose of the questionnaire, participation was voluntary and the anonymity of the participants was assured.

The questionnaire described above was **not** administered to the 2009 cohort. As mentioned earlier, the decision to include this cohort in the research was made only once the students had passed through the Centre. Consequently they were not available to respond to the questionnaire, and information pertaining to their travel arrangements and their motivational goals with respect to the biology module could not be included in the

2009 analysis. It was possible however to collect simplified information about these students' accommodation arrangements during their foundation year from the UKZN Student Housing office on the Pietermaritzburg campus. Again, once full data collation and cross checking was complete, these student numbers were removed from the data set, ensuring complete anonymity on the part of the student.

An updated ethical clearance certificate for the research, No. HSS/0655/09D (valid for doctoral study purposes) was issued at the beginning of 2012 (Appendix L).

Motivation score. The intention was to design an instrument that could generate quantitative data, i.e. a "score for motivation". Given the extensive literature on the subject, it was necessary to be very selective and focused when devising a research instrument to investigate student motivation in this study. In this regard, the adapted Inventory of School Motivation (ISM) of McInerney and colleagues' was found to be most useful. As Ali and McInerney (2005) point out, the ISM was formulated to be appropriate for both Western and non-Western students. The studies conducted after 2000, saw the instrument refined and a great reduction in the number of items included (for example, 25 in Yeung and Yeung (2001)).

Ali and McInerney (2005) reduced the ISM to include only the third component of Maehr's Personal Investment model (described by McInerney et al. (1997), and McInerney and Sinclair (1991)), namely **Personal incentives** (goals guiding performance as described above). This refers to the student's perceptions of the goals which guide action in a situation, and what a student might deem to be a "success" or a "failure". These are identified as being task, ego, social solidarity and extrinsic goals. Their study supported the usefulness of using the instrument to predict achievement outcomes, and in providing a motivational profile for students from a diversity of cultural backgrounds.

Inventory questions relating to the four perceived goals of behaviour given in Ali and McInerney (2005) and McInerney and Ali (2006) were selected and adapted to be appropriate for the Foundation Biology student cohort. Table 19 reflects the adapted questions. Responses to the items in each of the four scales were recorded on a 5-point Likert-type scale that ranged from strongly agree (5) to strongly disagree (1). Higher scores thus reflected more favourable responses to an item.

Table 19

Items of the Foundation Biology Motivation Scale and their Relationship to the Four Goals of Behaviour Described by Ali and McInerney (2005) and McInerney and Ali (2006)

Quest.No.	**1. Task goal (Mastery)** ***a. Task involvement***
1.	I have tried hard in Biology because I am interested in the subject.
14.	Understanding the work in Biology is more important to me than the mark I get for an assignment.
15.	I want to do well in Biology this year because it will enhance my performance in first year.
	b. Task effort/ striving for excellence
2.	I have tried hard to make sure that I perform well in Biology.
3.	I work hard to try and understand something new in Biology.
4.	The harder the task in Biology, the harder I try.
5.	When I perform well in Biology, I try even harder.
	2. Ego goal (Performance/Competition)
6.	I like to compete with others in Biology.
7.	I work hard in Biology so that I can do better than others in the subject.
	3. Extrinsic/ Intrinsic rewards
11.	I want to perform well in Biology for own sense of achievement.
12.	I want to perform well in Biology so I don’t let my parents/guardians down.
13.	Having other people tell me that I have done well in Biology is important to me.
	4. Social solidarity (Social concern)
8.	It is important for students to help each other in Biology.
9.	I like to help other students with their Biology work.
10.	I enjoy helping other students with their Biology even if I don’t perform that well myself.

Note. No questions relating to 2b (Social Power), 3a (Affiliation) or 4b (Token) were included in the Foundation Biology Motivation Questionnaire.

Motivation scale validity and reliability. Whilst acknowledging that a major assumption is made when conducting factor analysis[15] to establish scale validity (that is, "that algebraic factors represent real-world dimensions, the nature of which must be guessed at by inspecting which variables have loads on the same factor" (Field, 2009, p. 633), factor analysis was conducted on the 2008 Foundation student data collected by administering the questionnaire (Appendix M).

A principal component analysis (PCA) was conducted on the 15 item questionnaire with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy indicated a "good" sample size for factor analysis (Field, 2009) (KMO = 0.7). The KMO measure for individual items for two of the questions (questions 6 and 7) was less than 0.5 (both slightly more than 0.4). Removal of these items did not improve the KMO for multiple items above 0.7, and consequently the decision was taken to leave them in the questionnaire. Significance of Bartlett's test of sphericity χ^2 (105) = 356.990, $p < 0.001$, revealed relationships between the variables, indicating that factor analysis (PCA) was appropriate.

Initial principal components analysis revealed five components with eigenvalues greater than Kaiser's default criterion of 1; in combination these components accounted for 65.4% of the variance. However, communalities after extraction were not more than 0.7 for all questionnaire items. Furthermore, inflexions in the scree plot suggested that it may be better to extract six components, and indeed, doing this there was a reduction of the percentage of 'non-redundant residuals with absolute values greater than 0.05'. According to Field (2009, p.664) the proportion of residuals below 0.05 should be less than 50%; extracting a sixth component reduced this from 58% to a more acceptable 46%, and increased the variance explained to 71.8%. Six components were therefore retained in this analysis.

Normally when establishing the substantive importance of factor loadings (i.e. to gauge which questionnaire items make up each component (factor)), absolute value coefficients of 0.3 are considered important. It is important for the purposes of validation of this questionnaire that all 15 items had a loading of more than 0.3 for component 1 before rotation, suggesting an overall "motivation" scale with all 15 items clustering on this component.

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[15] In contrast to the use of the term "factor" until this point in the current research (see note 3, p. 25), the term "factor" in establishing motivation scale validity and reliability has specific statistical meaning, and in this context, is used to refer a "latent variable" in the multivariate technique known as factor analysis (Field, 2009, p. 786).

For interpretation of components and factor loadings **after** rotation, absolute value coefficients of less than 0.5 were suppressed, given the sample size of 79. This decision was based on the advice given by Stevens (2002) in Field (2009, p.644). Table 20 shows factor loadings after varimax rotation; items are listed in the order of size of their factor loadings. Items that clustered on the same components confirmed the existence of six components which reflected a very similar structure intended in the original questionnaire (albeit with a few minor differences) (refer to Table 19 above). Items loaded highly onto only one component. Component 1 represents questions 6 and 7 ("*ego goal/ competition"*), component 2 represents questions 9 and 10 ("*social solidarity*"), component 3 represents questions 1, 14 and 15 ("*task involvement*"), components 5 and 6 represent questions 2 and 3, and 4 and 5 respectively ("*task effort*"). Component 4 represents questions 11, 12 and 13 ("*extrinsic/ intrinsic* rewards"). Only question 8, loaded on component 4, seems to be misplaced.

Cronbach's coefficient alpha (α) represents a ratio of variance in the scale items attributable to the hypothesised variance to the amount of variance in error for each item. In other words "α is an estimate of the extent to which the responses to each item are due to the same underlying construct (i.e. the extent to which they measure the same thing)" (M. Quayle, personal communication, October 14, 2008). Overall, the scale consisting of all 15 items was judged to be reliable (Cronbach's Alpha coefficient of reliability, α = 0.78). Scrutiny of all *k*-1 versions of the full scale revealed no improvement in alpha. Subscale reliability alphas are given in Table 20. Subscales 1 to 5 were judged to be reliable, but component 6 (questions 4 and 5) had a relatively low reliability. Furthermore the reliability of subscale 4 (*Extrinsic/Intrinsic reward*) was improved by the removal of question 8. These judgements were based on the recommendations made in DeVellis (2003) where a score below 0.6 is unacceptable, between 0.65 and 0.7 "minimally acceptable", and one between 0.7 and 0.8 "respectable" (p.95). Field (2009) confirms that values for Cronbach's α of 0.8 are "good" (p.681).

Consequently questions 4, 5 and 8 were removed from the questionnaire and validity reassessed. Removal of these three items did nothing to change the Kaiser-Meyer-Olkin measure for sampling adequacy or the significance of Bartlett's test of sphericity. With extraction of five components, the proportion of residuals below 0.05 was 48% and 72.5% of the variance was explained. This revised questionnaire, with five components, was therefore retained in the final analysis. Table 21 provides a revised (varimax) rotated component matrix showing factor loadings for each of the remaining 12 items of the questionnaire. The 13 item scale remained reliable (Cronbach’s Alpha coefficient of reliability, α = 0.76). This modified questionnaire should thus be considered both valid and reliable.

Table 20

Rotated Component Matrix Showing Factor Loadings for each Item of Original Questionnaire (15 items)

	Rotated factor loadings					
	1	2	3	4	5	6
Question	*Competition*	*Social Solidarity*	*Task involvement*	*Ex/In reward*	*Task effort 1*	*Task effort 2*
6	0.92					
7	0.83					
9		0.84				
10		0.75				
15			0.75			
1			0.67			
14			0.63			
11				0.74		
13				0.66		
8				*0.57*		
12				0.50		
2					0.86	
3					0.77	
5						0.82
4						0.67
Eigenvalues	3.92	2.07	1.37	1.30	1.15	1.0
% of variance	26.12	13.81	9.14	8.70	7.64	6.41
α	0.8	0.8	0.6	0.6	0.65	0.5

Table 21

Rotated Component Matrix Showing Factor Loadings for each Item of Revised Questionnaire (12 items)

	Rotated factor loadings				
	1	2	3	4	5
Question	*Competition*	*Social Solidarity*	*Task involvement*	*Task effort*	*Ex/In reward*
6	0.92				
7	0.88				
10		0.84			
9		0.82			
15			0.76		
14			0.65		
1			0.64		
2				0.82	
3				0.82	
11					0.88
13					0.61
12					0.50
Eigenvalues	3.38	1.93	1.33	1.15	1.0
% of variance	28.17	16.07	11.12	9.55	7.63
α	0.8	0.8	0.6	0.65	0.65

Factor scores for each student were generated using the Anderson-Rubin method (for uncorrelated factor scores) (Field, 2009, p. 670). To calculate a single motivation score for each student, the five factor (component) scores of the revised questionnaire were added together to be included in classification and regression tree analysis. To explore which components of a student's motivation were most influential, each component was also added to the exploratory variable list ("*Competition", "Social solidarity", "Task involvement", "Task effort" and "Extrinsic/Intrinsic rewards").*

Method for Data Analysis

Classification and regression tree analyses, as described previously in Chapter 6, were again employed to analyse performance in the foundation modules. All the criteria for generating the trees were the same as for analysis of first-year Biology performance with the exception of the minima for parent and child nodes (set at 10 and 3 respectively for this analysis considering the sample size). Trees were constructed using all 79 and 88 students registered in the Foundation Programme in 2008 and 2009 respectively. Each cohort was analysed separately because of the different entrance criteria applied to each cohort as outlined in Tables 2 and 3 of Chapter 1.

Those explanatory variables included in the construction of trees are provided in Tables 22 and 23 below. Biographical and socio-economic data (accommodation, travel and financial support) were scored on the nominal scale. School history data was in most instances scored on an ordinal scale. Matric score, selection test scores and performance in foundation modules were continuous measurements. The outcome variable in all instances refers to the average final mark in each foundation module across the cohort, after supplementary exams have been written.

The "overall average" mark is calculated by averaging the final marks (also post supplementary exams) of all five foundation modules. The pass/exclude decision for each student is made on the basis of them passing (achieving above 50%) for all five foundation modules.

The following protocol was established to best explore the relative influence of the explanatory variables on Foundation student performance.

1. Regression trees were generated for performance in each of the five foundation modules in 2008 including all variables listed in Table 22.
2. In terms of selection criteria into the programme, the efficacy of the "Selection Model Score" and the constituent selection tests, relative to students' performances in matric science and maths subjects ("M score", see above) was evaluated by adding "M score" to the construction of the trees.

3. Once those variables most important in explaining performance in each of the 2008 foundation modules were identified, classification rule-syntax was generated to predict performance of the 2009 student cohort in each respective module.
4. Correlations between the actual and predicted performance in each foundation module of 2009 were evaluated to test the accuracy of the 2008 model to predict 2009 performance (to gauge reliability of those variables identified to explain student performance across cohorts, and schooling systems).
5. In the interests of refining the grounded theory emerging for each foundation module, and the programme as a whole, regression trees were then generated for performance in all 2009 modules including all variables listed in Table 23.
6. To explore students' overall performance in the foundation modules, steps 1 to 5 above were repeated with the outcome variable as their "overall average", i.e. a students' average mark across the five foundation modules. Finally, classification trees were generated using their pass or exclude status at the end of the foundation year as the outcome variable.

The results of this analysis are presented in the following chapter. The Foundation Biology module is dealt with first, followed by the other science modules and the Communication in Science module. Performance in the Programme as a whole is then examined by analysing students' average marks across the five modules and the proceed rates.

Table 22

Explanatory Variables Included in the Construction of Classification and Regression Trees (CART) for 2008 Foundation Student Group

Variable	Explanation
gender	Male or female
home language	Students were recorded as speaking either Zulu, Xhosa, Sotho, “other African language”, or English as a home language.
school quintile* Note 1	School attended was recorded from 1 (most under-resourced) through to 5 (most resourced) (see Chapter 1). Data retrieved from Department of Education website.
matric score	Refers to sum of admission points scored for all Senior Certificate subjects as described in Appendix A.
endorsement	Indicates whether students achieved the minimum statutory requirement for entry into mainstream study towards a Bachelor’s degree or not.
English as first or second language	Refers to whether students wrote Senior Certificate English as a first or second language.
English APS* Notes 2 and 3	Admission points scored for English as outlined in Appendix A.
Maths grade	Students had completed maths on either the higher or standard grade in 2007.
Maths APS* Note 4	Admission points score for maths as outlined in Appendix A.
Physical Science APS*Note 4	Admission points score for physical science as outlined in Appendix A.
Biology studied at school	Some students (9%) had not studied biology at school.
Biology grade	Students had completed biology on either the higher or standard grade (2007).
Biology APS* Note 4	Admission points scored for biology as outlined in Appendix A.
Maths selection test score	Score achieved in the maths selection test as outlined above.
Science selection test score	Score achieved in the science selection test as outlined above.
English SATAP test score	Score achieved in the Standardised Assessment Test for Access and Placement (SATAP) English for Academic Purposes Test (see Chapter 1).
Selection Model Score	Composite score outlined above.
Accommodation	Accommodation arrangements for duration of the Foundation year scored from 1 (lives at home), 2 (rented accommodation), 3 and 4 (in university residence for semester 2 or 1 respectively) through to 5 (in university residence all year).
Financial support	Financial support as outlined above scored from 1 (no financial support), 2 (R2 000 bursary), 3 and 4 (R2-4000 and R4-8000 bursaries respectively) through to 5 (granted financial aid).
Travel	Travel arrangements as outlined above, scored from 1 (travels more than 1 hour), 2 (travels less than 1 hour), 3 (lives off campus, but walks), 4 (lives on campus, easy walk).
Motivation	Factor scores indicating level of individual student’s level of motivation to succeed at academic studies as outlined above (Foundation Biology module only).

Notes.

1. Department of Education (2009c). Education management information systems - school addresses. Pretoria: Department of Education. Retrieved February 10, 2009, from http://www.education.gov.za/emis/getmis/addresses.htm

2. All 2008 students had completed English at school on Higher Grade in 2007.

3. English mark and symbol were initially included in the analysis, but dropped in preference for English APS, once the latter was shown to be a perfect surrogate for each of the former ($r = 0.967$, $p < 0.001$; $r = 1.00$, $p < 0.001$ respectively).

4. Different grades rendered comparison of marks and symbols achieved meaningless. APS for each school subject used in place of these scores.

5. Twenty four variables were included in the construction of the trees for Foundation Biology (Those above excluding Biology grade and APS initially as not all students had studied school Biology + Total Motivation + 5 motivation component scores). Biology APS and grade were included when exploring relative importance to “M score” (total of 27 variables in this analysis).

6. Twenty variables were included in the construction of the other Foundation modules as motivation was recorded only for performance in Foundation Biology.

Table 23

Nineteen Explanatory Variables Included in the Construction of Classification and Regression Trees (CART) for 2009 Foundation Student Group

Variable	Explanation
cohort	A distinction was made between those students who sat the Senior Certificate in 2007, and those who wrote the NSC exams in 2008.
gender	Male or female
home language	Students were recorded as speaking either Zulu, Xhosa, Sotho, “other African language” or English as a home language.
school quintile	School attended was recorded from 1 (most under-resourced) through to 5 (most resourced) (see Chapter 1).
matric score equivalent / matric score [1]	Matric score equivalent refers to sum of admission points scored for all NSC subjects as described in Appendix B, and normalised for the Senior Certificate students (Appendix C).
endorsement	Whether students achieved the minimum statutory requirement for entry into mainstream study towards a Bachelor’s degree or not.
English as first or second language	Refers to whether students wrote the Senior Certificate and the NSC English as a first or second language
English APS equivalent [23]	See Appendix C and above for explanation.
Maths APS equivalent[23]	See Appendix C and above for explanation.
Physical Science APS equivalent[23]	See Appendix C and above for explanation.
Biology/ Life Sciences studied at school	A small proportion (10%) of students had not studied biology/ life sciences at school.
Biology/ Life Sciences APS equivalent[23]	See Appendix C and above for explanation.
Maths selection test score	Score achieved in the maths selection test as outlined above.
Science selection test score	Score achieved in the science selection test as outlined above.
English SATAP test score	Score achieved in the Standardised Assessment Test for Access and Placement (SATAP) English for Academic Purposes Test (see Chapter 1).
Selection Model Score	Composite score outlined above.
Meets augmented requirements or not	53% of the 2009 group had met the Augmented stream minimum requirements but registered for the Foundation Programme instead.
Accommodation	Accommodation arrangements for duration of the Foundation year scored from 0 (not in university residence), 1 (university residence for semester 2 only) to 3 (in university residence all year).
Financial support	Financial support as outlined above scored from 0 (no financial support), 1 (granted financial aid), 2 (given R10-12000 bursary) to 3 (given R48 000 bursary)

Notes.

1. Unadjusted matric scores (total APS) for each cohort were used where "matric year" was forced as a primary splitter of the root node.

2. There was no grade distinction in 2008 for NSC subjects written.

3. Unadjusted subject APS scores for each cohort were used where "matric year" was forced as a primary splitter of the root node. Used in conjunction with the unadjusted matric score.

4. All nineteen variables were included in the construction of all the 2009 trees.

CHAPTER 9

Attempt to Answer Question 2 of Objective 3:
Factors Influencing Performance of Foundation Programme Students

Results and Grounded Theory Development

Question 2: What factors are most important in determining the performance of Foundation students in their access year?

Note: The grounded theory that emerges from the data analysis is written in italics after each section where results are presented.

Performance in the Foundation Biology Module

Of the 79 students in the 2008 cohort, seven had not studied Biology at school. Students' Biology APS scores were therefore excluded from the construction of the initial tree; only whether they had studied this subject at school or not was included in analysis (Figure 31). The variables that distinguished better student performance from those that struggled with Foundation Biology pertained to their English language proficiency. Indeed, to stand a good chance of passing the Foundation Biology module, it appears that it was necessary to achieve higher than a D symbol on Higher Grade or a B on Standard Grade English in the Senior Certificate (irrespective of whether this subject was taken as a first or second language). English language proficiency (as reflected by the SATAP and English APS scores) represented a 39% reduction in impurity in nodes 3 and 4 relative to the root node. There were no strong surrogates for either SATAP English test or school English performance and these two variables were deemed the most important for overall tree construction (as primary splitters and surrogates for other splits).

The motivation score was as (un)important as the selection model score in increasing homogeneity in the Foundation Biology mark (38.4% normalized importance), although there is no particular relationship between these two variables (r = 0.008, p > 0.05). An interesting relationship between performance and student motivation was found to exist. In the relatively better performing group of students – those in node 6 who had achieved more than a SG E in school physical science, those who were more motivated passed Foundation Biology (node 12, n= 12, M = 55%, SD = 5.52). In the weaker group (node 5) only those few scoring well below 50% had a high motivation score (node 10, n= 4, M = 35.7, SD = 3.78).

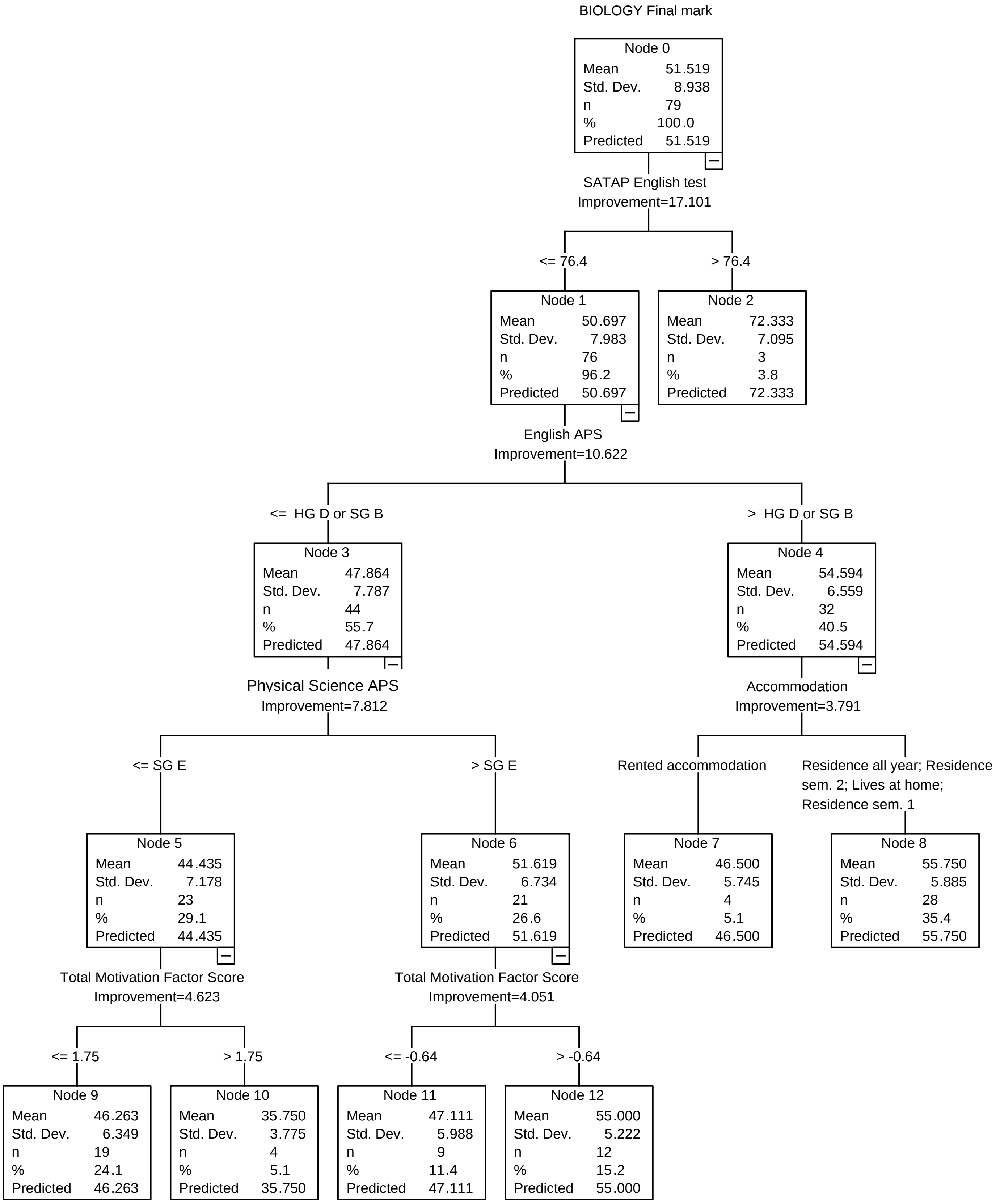


Figure 31. Regression tree for 2008 final marks for the Foundation Biology module (099 and 199) (*N* = 79).

Generally underperforming students – those who underperformed in school English and school physical science, were unmotivated too. It appears that a higher motivation score was associated with better performance if students were not particularly weak in more than one area (weaker in English, but relatively better in physical science).

To explore the influence of the components of motivation, the "total motivation score" was removed from tree-construction. Only the "competition score" was found to be the primary splitter of any node in the absence of a general score for motivation. The heterogeneity of only node 5 was reduced by this variable, this being the group of students who were weaker in both English and physical science. It appears that of this group, only the really weak were motivated to perform better (node 10, *n* = 12, *M* = 40.67, *SD* = 6.55). The remaining students were generally unmotivated, preferring not to compete with fellow students to improve their performance (node 9, *n* = 11, *M* = 48.55, *SD* = 5.52).

To return to Figure 31, of those students who achieved better in school English (node 4), the influence of having accommodation in the University residence is apparent with these students achieving higher final Foundation Biology marks than those students who rented private accommodation.

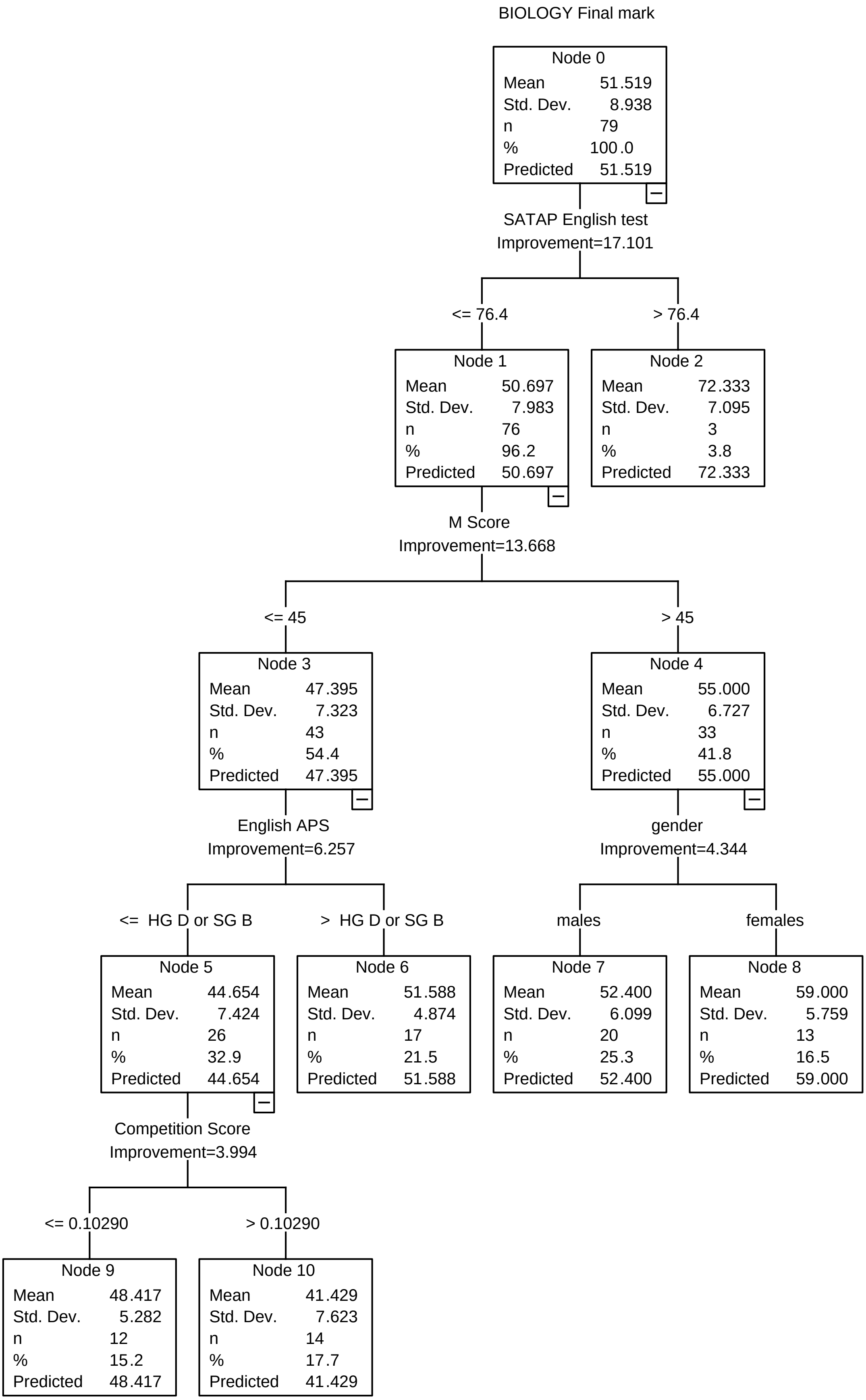
The "selection model score" did not feature as a primary splitter and appeared only as a relatively weak surrogate for Physical Science APS when splitting node 3 (improvement in purity = 1.13, λ coefficient for contingency tables = 0.67) and for the "motivation score" to split node 5 (improvement in purity = 2.87, λ coefficient for contingency tables = 0.25).

Whether students had studied Biology at school or not was not important; neither was their performance in school maths nor, in particular, the science selection test (ranked 21, 22 and 18 out of 24 variables respectively in terms of normalised importance to overall tree construction). Matric score, ranked 13, also had little influence over performance in Foundation Biology (12.1% normalised importance and did not appear as a viable surrogate for any primary splitter).

With the addition of the "M score" to tree construction, it became apparent that this score was a good indicator of success in the Foundation Biology module (Figure 32). Indeed, relative to SATAP English test (100% normalised importance), the "M score" was the second most important variable in the construction of the tree (64%). The selection model score was not a good surrogate for the "M score" in splitting node 1 (improvement in purity = 2.70, λ coefficient for contingency tables = 0.61) and ranked 20 out of the 24 variables in terms of importance to general tree construction. The score for general motivation was shown again to be unhelpful in determining a students' achievement in the Foundation Biology module (ranking 21 out of 24 variables in terms of importance to tree construction). Those students who performed poorly at school (as indicated by the "M score" and English APS) were not motivated to push their final Foundation Biology mark up to a pass by being competitive (node 9, $n = 12$, $M = 48.42$, $SD = 5.28$). Those who had little hope of passing Foundation Biology continued to be more highly motivated. This is a reflection of the trend seen in Figure 31. Given this, it is unlikely that a score for motivation would be useful in selecting students for better performance in the Foundation Biology module.

To explore the relative importance of the students' Biology APS to the "M score", this variable was then introduced to construct a tree (given that it was initially omitted because some of the students had not studied Biology at school). Very little difference was seen in this tree with SATAP English remaining the primary splitter of the root node and "M score" continuing to reduce heterogeneity in node 1. Biology APS was shown to be the primary splitter of the group of weaker students (those achieving less than an "M score" of 45), but was only responsible for revealing the influence of a few, very weak students who had achieved less than a SG E in school Biology (node 5 of un-displayed tree including Biology APS, $n = 4$, $M = 35.75$, $SD = 5.74$). As in Figure 32 (without Biology APS), those achieving more than SG E for school Biology, were subsequently separated on the basis of their school English performance. Performance in School Biology was thus shown to have less of an impact on student performance in the Foundation Biology module than English language proficiency and "M score".

Given the importance of the SATAP English test and the "M score" in explaining students' performance in the Foundation Biology module, syntax for the classification rules was generated using only these two variables (Appendix N). Students' predicted Foundation Biology mark and their actual 2009 mark for this module were significantly correlated ($r = 0.38$, $p < 0.01$), this being considered a medium to large effect (Field, 2009).



. *Figure 32.* Regression tree for 2008 final marks for Foundation Biology module (099 and 199) (*N* = 79). “M Score” included in the construction of the tree.

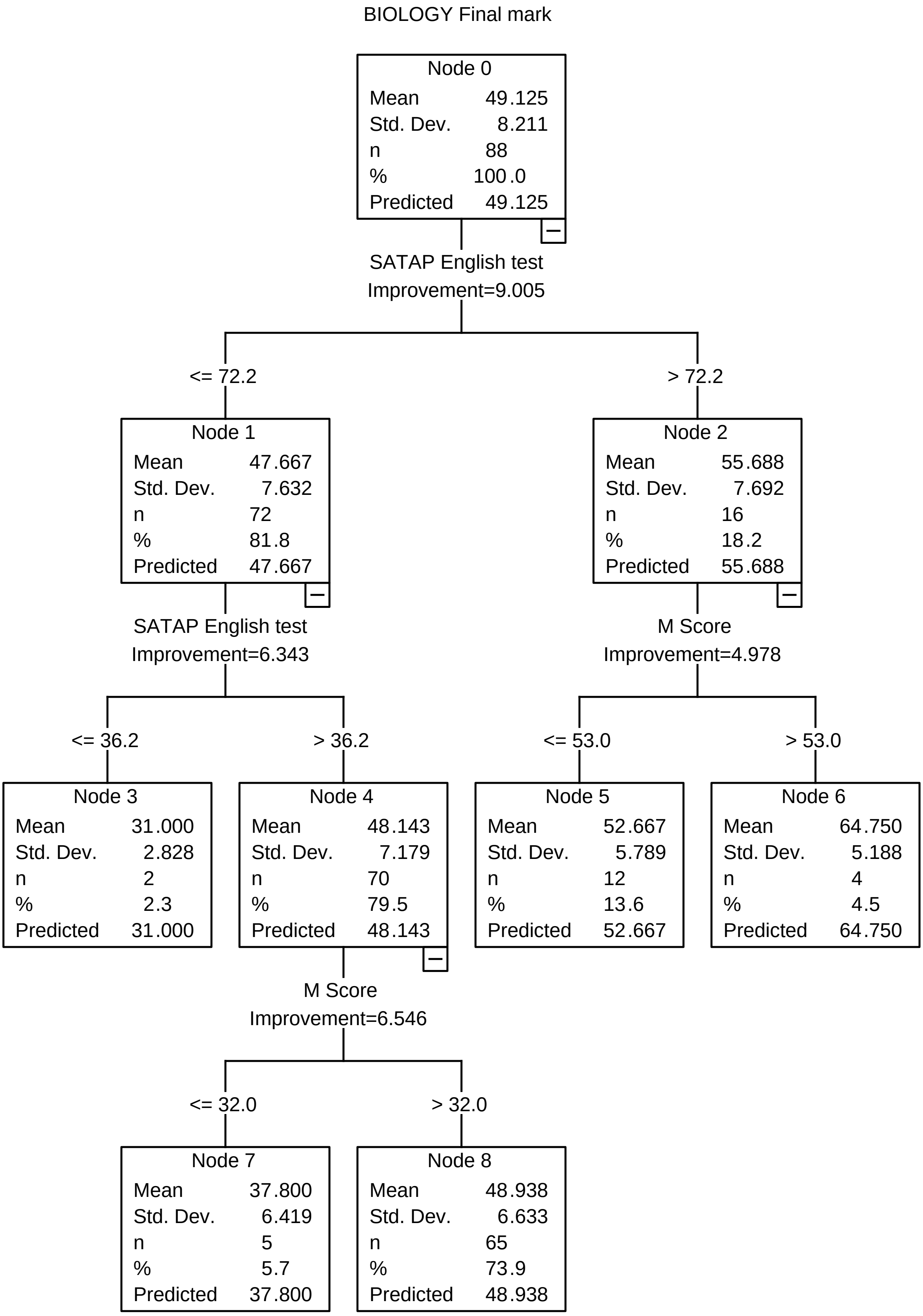


Figure 33. Regression tree for 2009 final marks for Foundation Biology module (099 and 199) (*N* = 88). “M Score” included in the construction of the tree.

A tree that is reflective of 2008 trends was generated for the 2009 Foundation Biology module (Figure 33). Of the 20 variables included in the generation of the tree only "M score" and SATAP English were revealed as primary splitters within the parameters set for tree construction (described in Chapter 6 and minima for parent and child nodes set at 10 and 3 as described above). "M score" was added to those variables listed in Table 23 to construct this tree based on its prevalence in explaining performance in 2008 Foundation Biology. No good surrogates were found for SATAP English test results to split the root node. The selection model score was found to be a perfect surrogate for the "M score" as the primary splitter for node 2 (improvement in purity = 4.98, λ coefficient for contingency tables = 0.98), suggesting that for these higher achieving students in node 2, their school performance was more in line with their performance in the selection tests in 2009 than was the case in 2008. This is supported by the ranking of the maths selection test in third place after "M score" and SATAP English test results in terms of importance to overall tree construction. Performance in Biology APS was ranked 11 out of the 19 included variables, not particularly important as suggested in the construction of the 2008 trees. Matric score (and "matric score equivalent") featured even lower than this in terms of overall importance to tree construction. Performance of school maths was shown to be more important for the 2009 cohort than was the case in 2008 (ranked 10th out of 19 variables).

The tree in Figure 33 is not particularly helpful in establishing a value of "M score" that could be used as a good predictor of success (achieving more than 50%) in the Foundation Biology module. What is clear though is that an absolute minimum of 32 points for the "M score" is required for borderline performance in the Foundation Biology module (node 8, *n* = 65, *M* = 48.94, *SD* = 6.6). To stand a better chance of passing, it can be assumed that an "M score" higher than this is required to pass, and to improve performance further, it would be preferable to have higher levels of English language proficiency as indicated by the SATAP English test mark.

Given the recurring appearance of the SATAP English test mark and "M score" in determining performance in both 2008 and 2009 as shown a number of times above, a theory for performance in the Foundation Biology module has emerged. The "selection model score" as applied in selecting students for entry into both 2008 and 2009 has not been particularly useful for the Foundation Biology module; *clearly students are not being* *appropriately selected for success in this particular module.* Furthermore performance in the individual maths and science selection tests was not a good indicator of potential in the Foundation Biology module. *Selecting students based on their levels of motivation would not be useful either.* As far as the Foundation Biology module is concerned, a closer look at the role the "M score" plays in determining performance in the other Foundation modules is required to best select students for optimal performance in this module as well as other core modules.

Perhaps most importantly, the tension between access to, and success in, the Foundation Biology module, comes to the fore. In terms of redress, and widening access to tertiary education to a greater number of educationally disadvantaged students, *to select students on the basis of their language proficiency would be patently contradictory. It would seem that remediation* ***in*** *the Foundation Biology module, rather than* ***access to*** *it, is a more appropriate response to English language proficiency when dealing with foundation students.*

Performance in the Foundation Chemistry Module

The variable that best explained performance in the Foundation Chemistry module was the selection model score generated to select students into the Foundation Programme (Figure 34). Relative to the within-node variance of the root (87.84), the impurity change represented by the selection model score (20.07) represented 23% reduction in heterogeneity in the daughter nodes. Those students who fell into the first node (those achieving less than 56 selection model points) had an average of 51.8% (*SD* = 8.43), whilst those achieving more than 56 points, performed much better in the Foundation Chemistry module (*M* = 61.35, *SD* = 9.35). Students in node 1 were further distinguished by their English language proficiency (improvement in purity = 9.70); financial support reducing heterogeneity of this node almost as well (improvement in purity = 9.54, λ coefficient for contingency tables = 0.45).

In terms of importance in overall tree construction the selection model score was ranked first, followed by SATAP English test results, financial support and school Physical Science APS (normalised importance being 96%, 80% and 71% respectively in the list of 20 explanatory variables included in the construction of trees for this module, there being no score for "motivation for chemistry"). Physical Science APS was shown to be a good surrogate for the selection model score in splitting the root node (improvement in purity = 14.55, λ coefficient for contingency tables = 0.43). When included "M score" was shown to be a relatively good surrogate for the selection model score (improvement in purity = 12.65, λ coefficient for contingency tables = 0.54), but was not exposed as a primary splitter of any node.

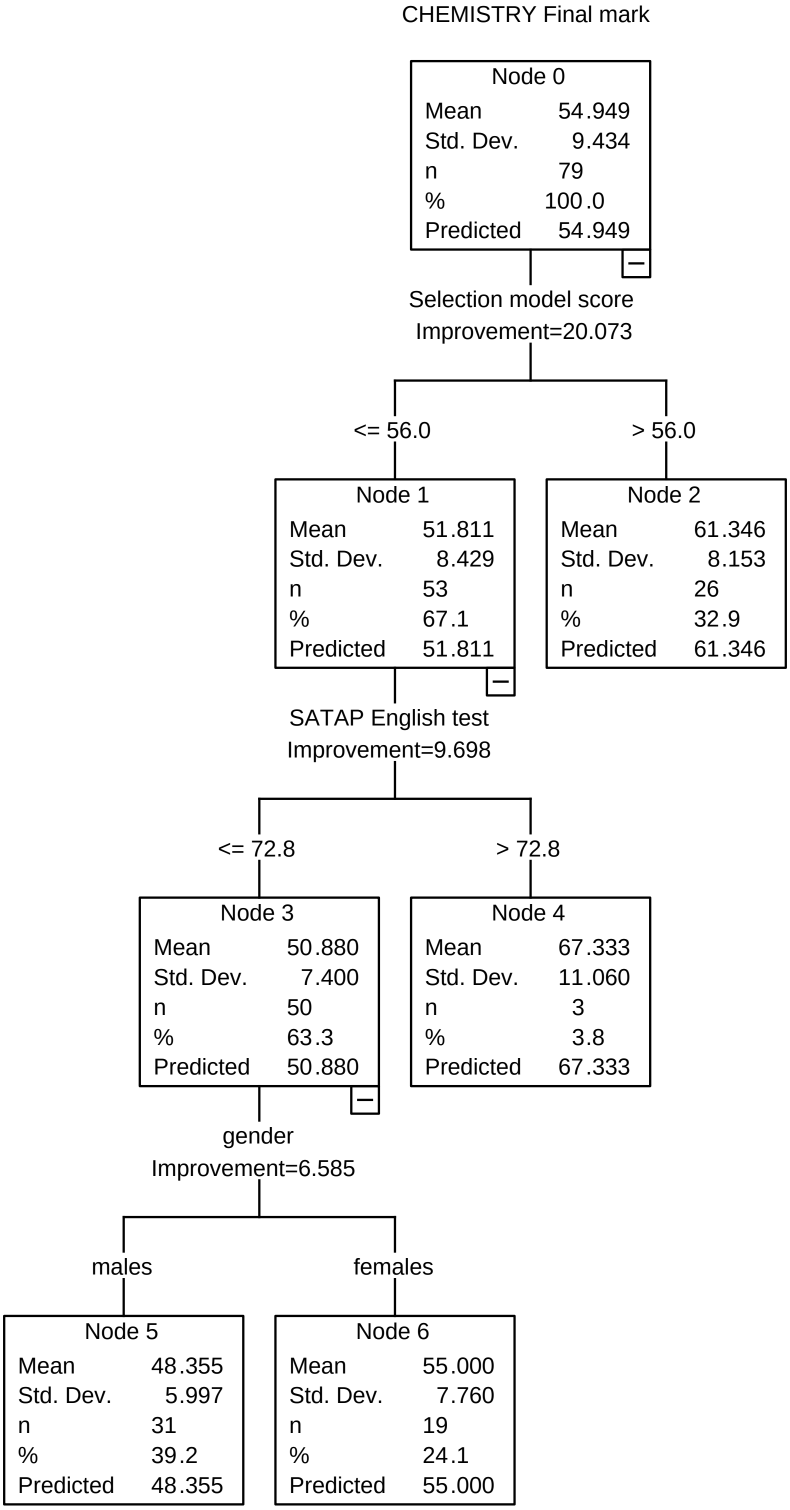


Figure 34. Regression tree for 2008 final marks for Foundation Chemistry module (099 and 199) (*N* = 79).

Using only the selection model score it was possible to fairly accurately predict students' marks for the 2009 Foundation Chemistry module. Syntax for the classification rules was generated using only this variable from the 2008 data (Appendix O); the resulting predicted and actual 2009 Foundation Chemistry marks correlated significantly well (r = 0.48, p < 0.01). Generating classification rules **without** using the selection model score, but including "M score" in conjunction with other variables revealed in an exploratory tree (a complex combination of many of the explanatory variables) revealed that "M score" cannot be used to predict student performance in this module (predicted and actual Chemistry marks for 2009, r = 0.13, p > 0.05). This suggests that the selection tests are important components of the selection model score when it comes to selecting students for Foundation Chemistry.

The above trends were reiterated in the construction of the regression tree for the 2009 Foundation Chemistry module (Figure 35). Relative to the within-node variance of the root (144.23), the impurity change represented by the selection model score (25.45) represented 18% reduction in within-node variance. Those students who achieved more than 56.6 in the selection model score did significantly better than those who scored lower than this (node 1, M = 47.48, SD = 10.76; node 2, M = 58.21, SD = 11.55), $t(86) = 4.29$, p < 0.001, r = 0.5 (two-tailed). Thus both the 2008 and the 2009 models identified 56/57 as the cut-off selection model score for success in the module. Given that the score for automatic selection into the Foundation Programme has in the past been 52, this suggests that the selection model is effective in identifying students with potential in Chemistry, but the cut-off value needs to be revisited. Once more in 2009, as seen in 2008, when "M score" was added to the list of variables to construct the tree, it was shown to be a very poor surrogate for the selection model score (improvement in purity = 1.25, λ coefficient for contingency tables = 0.34). The matric score equivalent (and un-normalised matric score) were not good surrogates, and reduced the heterogeneity by comparatively very small amounts.

The heterogeneity in the student body in terms of Chemistry final mark was further reduced by 10% by taking into account the influence of financial support (improvement in purity = 11.52) (Figure 35). Only English SATAP test results existed as a possible alternative as splitter of this node (improvement in purity = 8.74). Furthermore, although a very poor surrogate for the selection model score (and not a primary splitter in the tree generated), accommodation was also found to have potential in reducing the heterogeneity in the root node in terms of performance in the Chemistry module (improvement in purity = 18.77, λ coefficient for contingency tables = 0.07). The influence of financial support on a student's performance in the Foundation Chemistry module has already been seen in 2008 where this variable was ranked as the third most important factor (out of 20) in generating the tree. In 2009, financial support ranked second after selection model score in terms of overall importance to performance in the Chemistry module (out of 19), accommodation and SATAP English score following in third and fourth places respectively.

The selection model appears to have been effective in identifying students with potential to perform well in Foundation Chemistry. It would appear that once students are given **access** to the Programme on the basis of achieving more than a score of 56 in the selection model, their ***success** in the module could be better ensured through the provision of financial support.* Access to, and success in, the Biology and Chemistry Foundation modules were clearly not contingent on the same factors, although there was a commonality of the peripheral influence of the English SATAP test results.

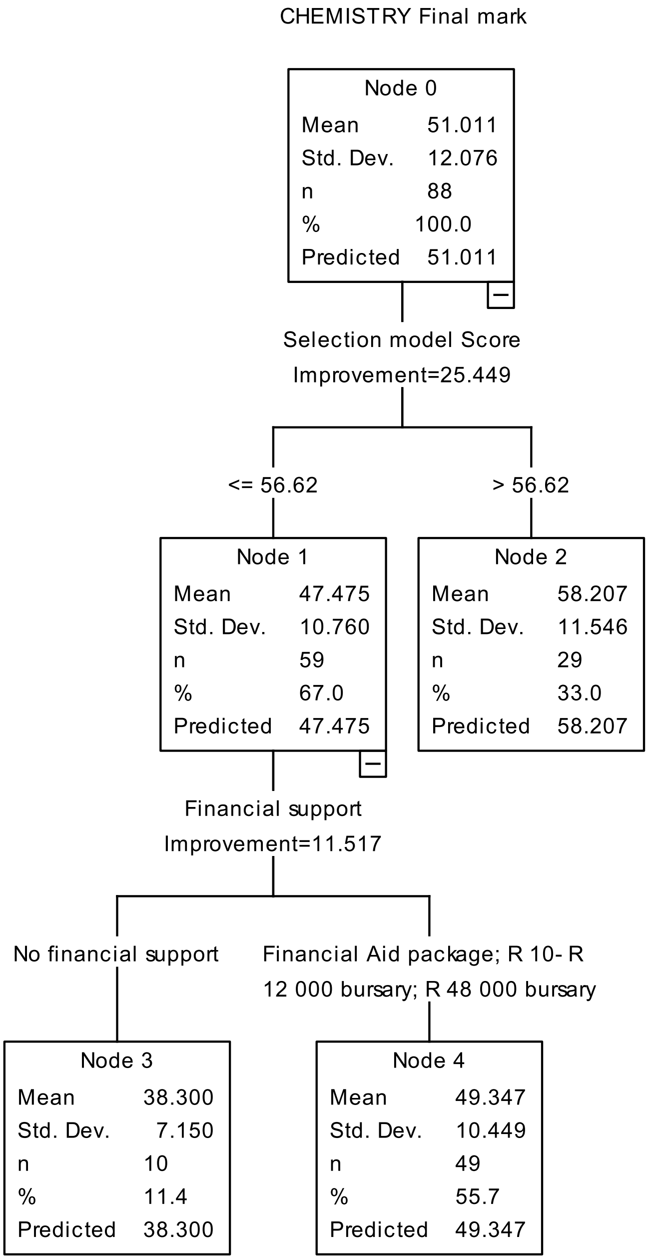


Figure 35. Regression tree for 2009 final marks for Foundation Chemistry module (099 and 199) (*N* = 88).

Performance in the Foundation Physics Module

Performance in the Foundation Physics module in 2008 could be explained, very simply, in terms of the selection model score (Figure 36). Using the same criteria for generating the regression trees for the Foundation Biology and Chemistry modules, only this variable was able to reduce heterogeneity within the root node. Relative to the within-node variance of the root (82.85), the impurity change represented by this variable (31.09) represented almost 40% reduction in within-node variance. Those students who scored more than 55.6 in the selection model (node 2) did significantly better in the Foundation Physics module than those who scored less than this (node 1) (M = 62.85, SD = 7.71; M = 51.10, SD = 7.07), $t(77) = 6.80$, $p < 0.001$, $r = 0.6$ (two-tailed).

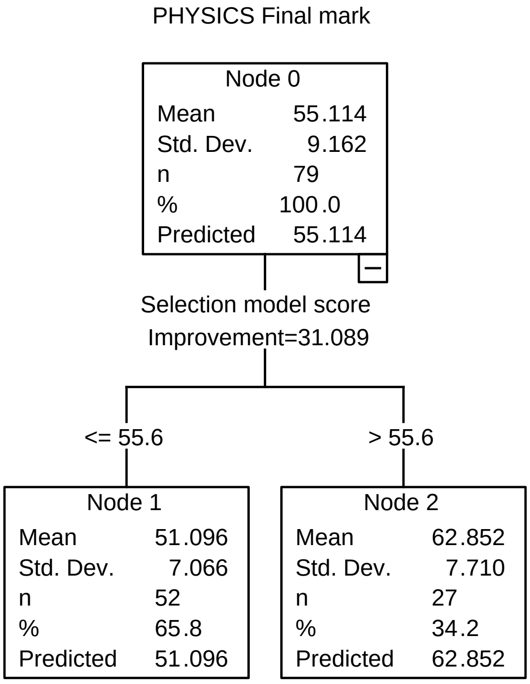


Figure 36. Regression tree for 2008 final marks for Foundation Physics module (099 and 199) (N = 79).

Relative to the selection model score, only Physical Science APS played some role in generating the tree (53.3% relative normalised importance) and no surrogates were identified for the selection model. Matric score reduced the heterogeneity of the root node by a very small amount (improvement in purity = 4.08). When included in analysis, “M score” was found to be a weak surrogate in terms of reduction in impurity, although the association value with selection model score was high (improvement in purity = 13.69, λ coefficient for contingency tables = 0.59).

Given the importance of the selection model score in explaining students’ performance in the Foundation Physics module, syntax for the classification rules was generated using only this variable (Appendix O). The actual mark achieved by students in the Foundation Physics module in 2009 was significantly correlated with the marks predicted by the model generated from the 2008 regression tree for performance in this module, ($r = 0.37$, $p < 0.01$), this being considered a medium effect (Field, 2009). The isolated “M score” was shown to have no value in predicting the 2009 Foundation Physics marks, as was found for the Chemistry module (predicted and actual Physics marks for 2009, $r = 0.07$, $p > 0.05$ using “M score” in conjunction with variables revealed important in absence of selection model score).

The regression tree describing performance in the Foundation Physics module in 2009 was somewhat more complex, but the reiteration of the importance of the selection model score is clear. Indeed the selection model score distinguishing better students from those who are borderline was the same for Physics as it was for Chemistry in 2009, i.e. 56.6 (Figure 37). Those students who did not achieve more than 57 selection model points did not, on average, actually fail the Foundation Physics module, but their performance was considerably weaker, and students in this group did run the risk of failure in this module (node 1, $M = 52.49$, $SD = 8.13$). As was found in 2008 (and indeed an iteration of both Chemistry module cohorts too), the “M score” was a very weak surrogate for the selection model score in explaining performance in the 2009 Physics module (improvement in purity = 2.14, λ coefficient for contingency tables = 0.28).

Although the selection model score was found to be the primary splitter of the root node in 2009, accommodation was the most important variable for the overall construction of the tree (selection model score ranked second out of the 19 explanatory variables for

2009). Certainly within the group of students who achieved lower selection model scores, this factor was crucial in 2009, with those students not in residence failing the Foundation Physics module (node 3, *M* = 48.89, *SD* = 7.68). Compounded with the selection model score, the influence of accommodation reduced the heterogeneity in the final Physics marks by 33%.

In the group of students who achieved more than 57 selection model points, those who had better school biology/ life science marks actually performed more poorly in Foundation Physics than those with lower school biology/ life science marks (nodes 6 and 5, *M* = 54.73, *SD* = 10.37 and *M* = 67.17, *SD* = 8.68 respectively). This inverse relationship was compounded for these stronger Biology students in that those that had higher levels of English language proficiency, on average, actually failed Foundation Physics! (node 10 *M* = 47.60, *SD* = 9.60). This trend is reflected in the significant positive correlation between Biology/ Life Science APS and English APS for the 2009 cohort ($r = 0.45$, $p < 0.01$), and the significant negative correlation between English APS and final Foundation Physics mark ($r = -0.22$, $p < 0.05$). It is feasible to assume that this inverse relationship might have existed as a result of students meeting the requirements for entrance to the Programme through school English, maths and biology/ life sciences rather than school English, maths and physical sciences. If this was so, their foundation in physics and chemistry would understandably have been weak since they hadn't studied this at school. This was not the case however; only one out of all 88 2009 Foundation students had not done physical science at school.

There is growing evidence to support the theory that the CSA selection model is effective in terms of selecting students for potential in the "hard sciences", that is, at this point, Chemistry and Physics. However, those students who, prior to selection, have been shown to be better at biology/ life science, appear to struggle with their Foundation Physics module, and indeed are compromised even further if their strength is English proficiency instead. Clearly the Foundation Programme access mechanisms do not necessarily facilitate success for those students who have an aptitude for the Life Sciences. Conversely, selecting students on the basis of language proficiency would mean exclusion for those whose potential lies elsewhere. Once given access to the Programme, the success of some students (specifically those who are academically weaker) is determined by support in non-academic spheres such as accommodation, and financial support.

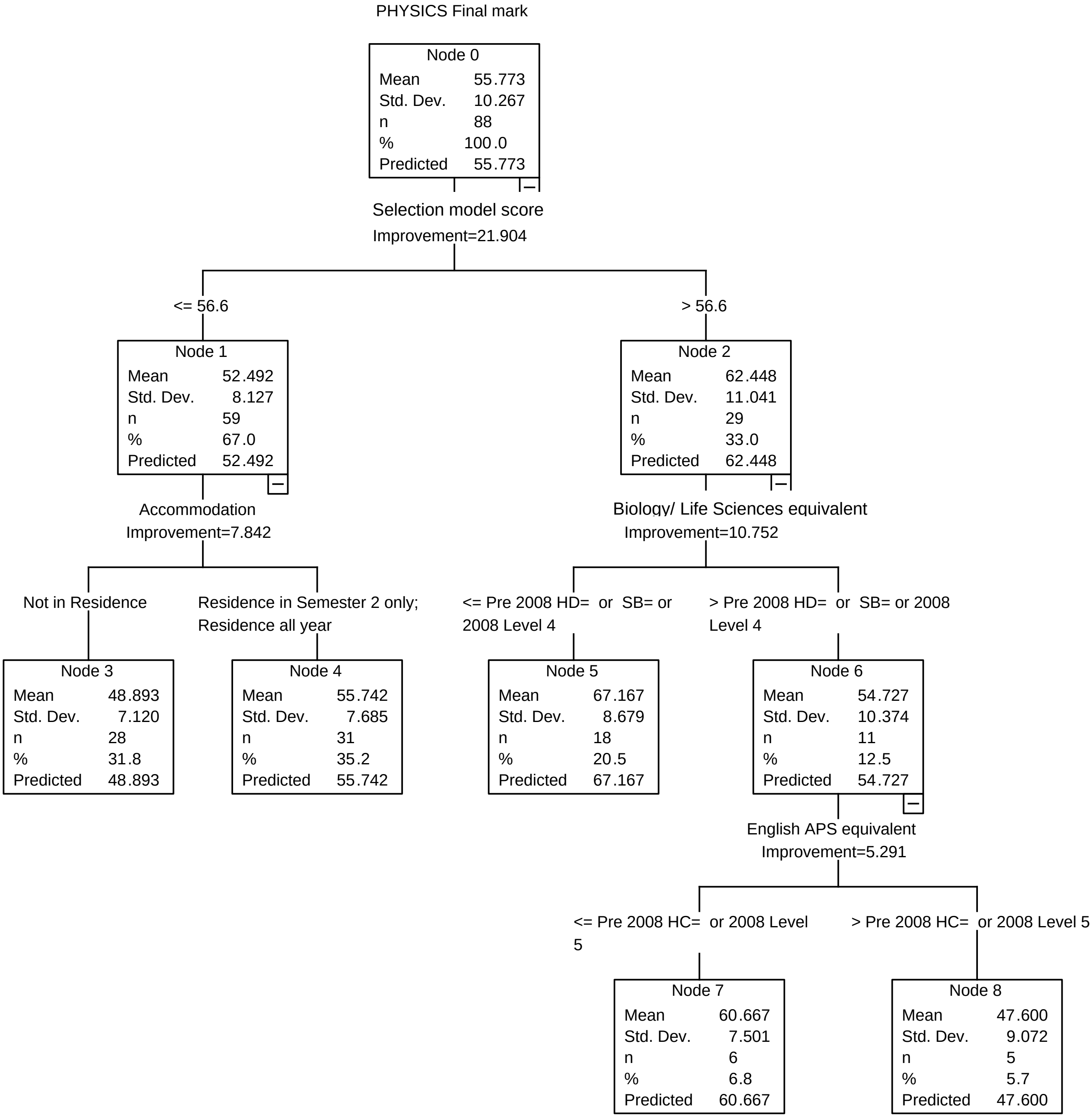


Figure 37. Regression tree for 2009 final marks for Foundation Physics module (099 and 199) (N = 88).

Performance in the Foundation Mathematics Module

The selection model score, once again, was shown to best reduce heterogeneity in the root node in the mathematics module in 2008 (by 24% in this instance) (Figure 38). Furthermore, the cut-off value distinguishing the better performing students from those who did not perform as well was very similar to that revealed in the 2008 trees for Chemistry and Physics (a selection model score of around 56). Those students in node 1 did not, on average, fail Foundation Mathematics, but it is worth noting that the average mark for this module was considerably more than the average in the other science foundation modules (node 0, *M* = 61.84, *SD* = 12.5 in comparison to averages in the low- to mid-50s for the other modules). The influence of financial support was clearly evident in this tree, with both the better and weaker students achieving higher foundation maths results if given financial support. No surrogates reduced impurity in daughter nodes to the same extent as these primary splitters (selection model score and financial support which ranked first and second in terms of importance in overall tree construction).

At first glance, the influence of travel appeared unclear with those students both travelling long distances and living on campus performing better than those who live off campus, but walk (nodes 3 and 4 respectively). However, accommodation acted as an effective surrogate for travel in this tree, with those students in node 4 renting accommodation (improvement in purity = 9.305, λ coefficient for contingency tables = 0.42). Rented accommodation was also found to have a negative impact on performance in Foundation Biology in 2008.

The only additional variable having some noteworthy influence (and not revealed in the tree) was Maths APS which ranked third in importance (55%) and acted as a weak surrogate for the selection model score in splitting the root node (improvement in purity = 18.81, λ coefficient for contingency tables = 0.19). Matric score had almost no influence (9% normalised importance). When included in analysis, “M score” was shown to be weaker than Maths APS in reducing impurity, although the association value with selection model score was higher (improvement in purity = 11.95, λ coefficient for contingency tables = 0.42).

Syntax for the classification rules for the 2008 tree was generated using only the selection model score (Appendix P). The actual mark achieved by 2009 students in this module correlated significantly well with the marks predicted by the model generated using this syntax ($r = 0.42$, $p < 0.01$), this being considered a medium to large effect (Field, 2009). The "M score" was shown to have no value whatsoever in predicting the 2009 Mathematics marks, as was found for both the Chemistry and Physics modules (predicted and actual Mathematics marks for 2009, $r = 0.009$, $p > 0.05$ using "M score in conjunction with other variables revealed important in absence of selection model score).

The regression tree generated for Foundation Maths in 2009 revealed the importance of the maths selection test as a primary splitter of the root node for the first time to date with those students achieving more than 72% in this test, performing very well in the Mathematics module (Figure 39). This does seem to suggest that there is greater alignment between the post-2008 NSC school curriculum and the maths test used to select students into the Foundation Programme than was previously the case. The selection model score as a whole was not nearly as effective in reducing impurity in the root node as was the individual maths selection test (improvement in purity = 15.77, λ coefficient for contingency tables = 0.47). This suggests that, in terms of performance in Foundation Mathematics in particular, the "M score" and the science selection test components of the selection model score detracted from its efficiency as a selection tool (improvement in purity = 13.23, λ coefficient for contingency tables = 0.06; improvement in purity = 3.52, λ coefficient for contingency tables = 0.24 for "M score and science selection test respectively). Matric score equivalent (and matric score) continued to have little influence.

Most striking in this tree, is the iteration of the inverse relationship that existed between performance in this foundation module and proficiency in English as was seen in the 2009 Physics module. Those students who scored above 71% in the English SATAP test did particularly poorly in the mathematics module (node 4, $M = 44.71$, $SD = 11.92$). Indeed, in this cohort a small negative correlation was found to exist between performance in the English SATAP test and the mark in the Foundation Mathematics module ($r = 0.15$, $p > 0.05$). Seelen (2002), having found similar negative relationships between performance in school English and performance in mainstream faculty of science students at the University of Lesotho, calls for the relaxation of entry requirements pertaining to English language proficiency as measured by performance in school English.

The mathematics selection test is an important component of the selection model score, particularly as an indicator of potential in the Foundation Mathematics modules. Where the "M score" is not an effective indicator of success here, nor in the Chemistry and Physics modules, it is important in the one module that has been shown to benefit from higher levels of English language proficiency (that is the Biology module). It would appear that the CSA selection mechanism places greater pressure on the Foundation Biology module than on the other modules in terms of ensuring student success after granting access to the Programme. The importance of providing socio-economic support in the form of places in residence and financial assistance, particularly to those students who are shown by the selection model score to be academically weaker on entering the Access Programme, must be acknowledged if students are to achieve their potential in the Chemistry, Physics and Mathematics modules.

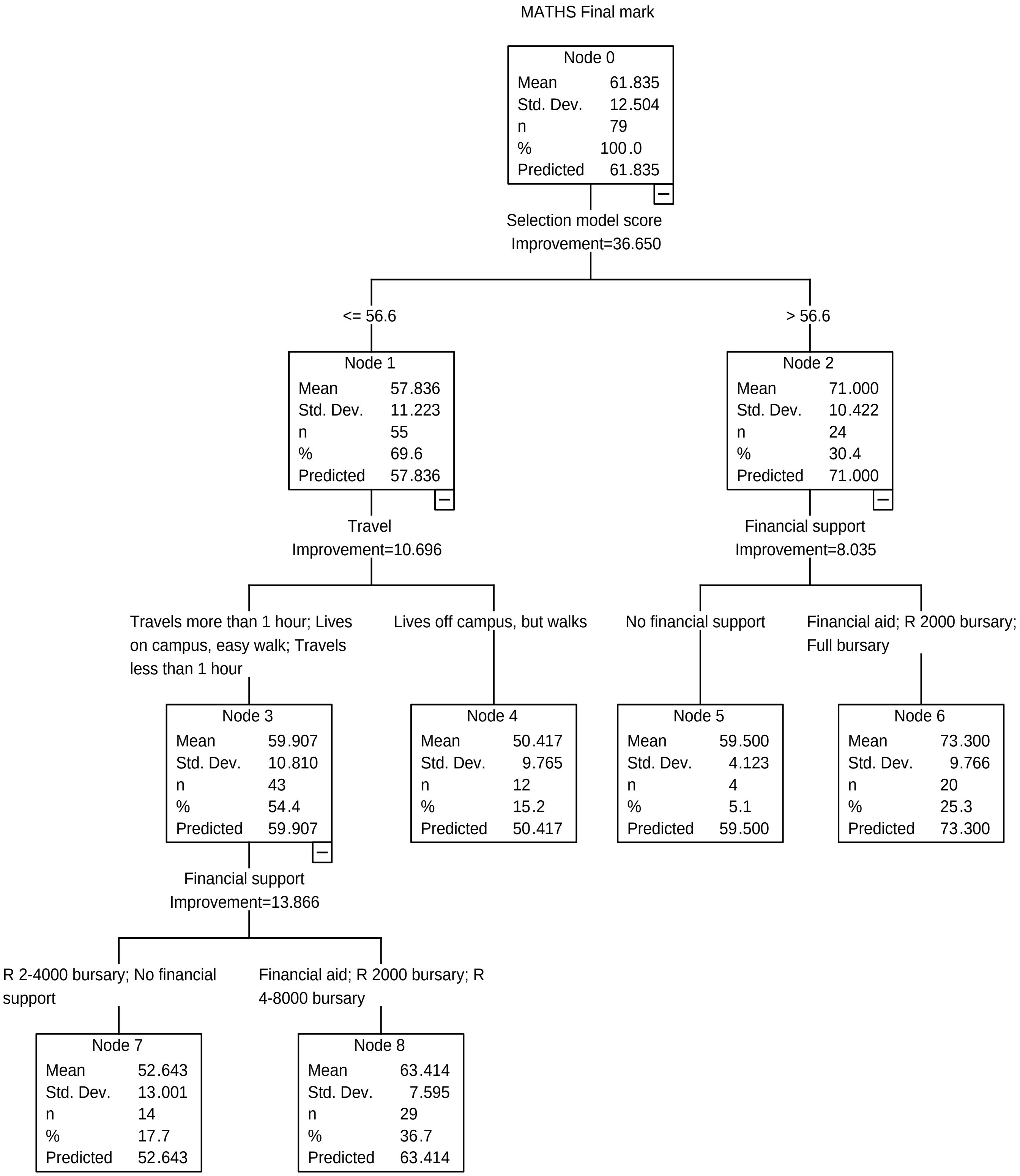


Figure 38. Regression tree for 2008 final marks for Foundation Mathematics module (099 and 199) (*N* = 79*).*

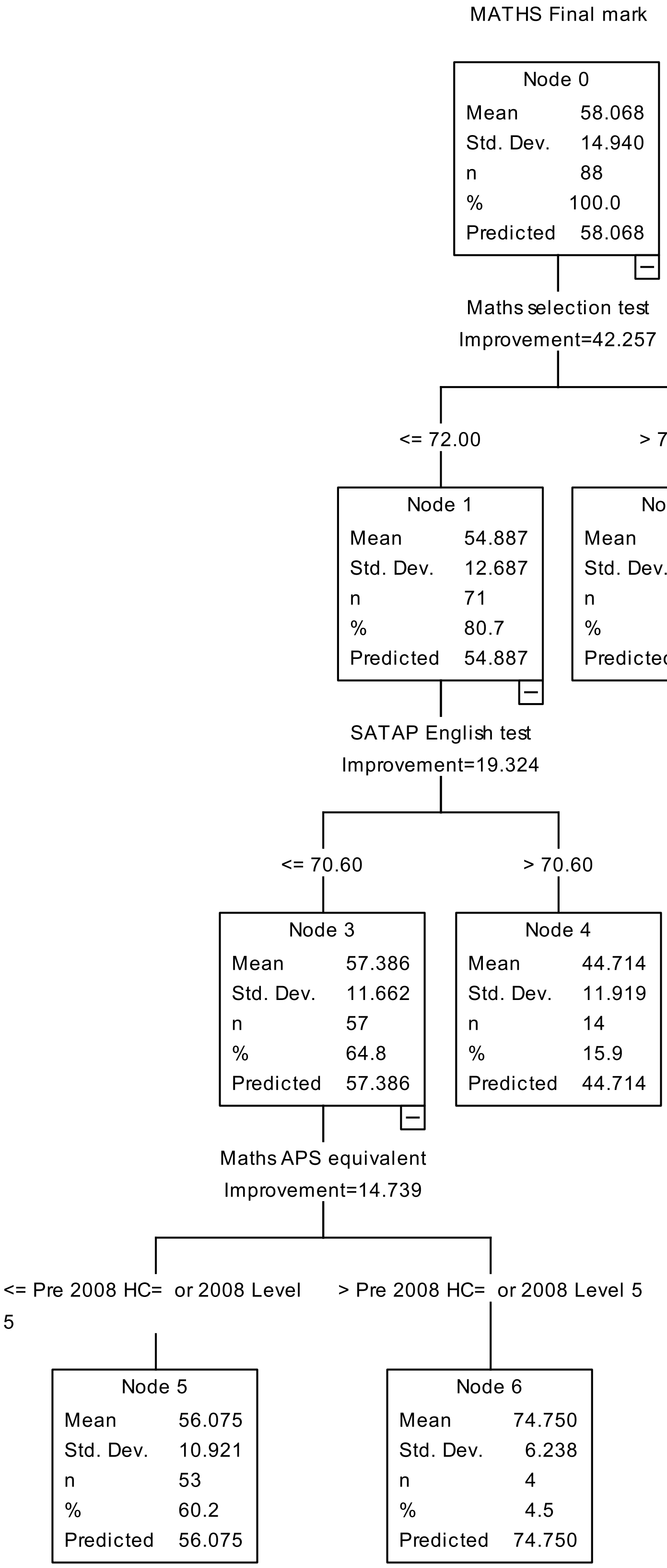


Figure 39. Regression tree for 2009 final marks for Foundation Mathematics module (099 and 199) (*N* = 88).

Performance in the Communication in Science Module

Prior to 2009 students were not required to have achieved a minimum level of English language proficiency to gain access to the Foundation Programme (see Table 3, Chapter 1). From 2009, they had to have achieved at least level 4 in NSC English (as first or second language). This was reflected in the regression trees for the Scientific Communication modules of 2008 and 2009 (Figures 40 and 41 respectively). In 2008 the SATAP English test score reduced heterogeneity in the Communication in Science final mark by 20%; the English APS further improved node purity by 15% in the weaker group of students (node 1, $M = 55.68$, $SD = 5.58$). There were no good surrogates for either of these primary splitters, the most feasible being financial support (as splitter of the root node) (improvement in purity = 3.70, λ coefficient for contingency tables = 0.19). Although this variable (financial support) was revealed as the primary splitter of the root node in 2009 (Figure 41), it was possible to fairly accurately predict performance in this module on the basis of syntax generated from the 2008 cohort using only SATAP English test scores (Appendix Q) (predicted and actual Communication in Science marks for 2009, $r = 0.30$, $p < 0.01$). This correlation was improved only marginally by including the English APS in the rules to generate the regression tree (predicted and actual Communication in Science marks for 2009, $r = 0.34$, $p < 0.01$). In spite of the importance of financial aid in reducing heterogeneity in the root node, it was the SATAP English test score that was most important in the generation of the whole tree. This suggests that implementing the access criterion of level 4 school English from 2009 had only alleviated the influence of English language proficiency to a point.

The influence of financial support on performance in this module was unmistakable in 2009. Those students who received bursaries in 2009 did better than those who did not (nodes 1 and 2, $M = 61.11$, $SD = 5.88$ and $M = 56.26$, $SD = 5.08$ respectively). In terms of overall construction of the tree however, financial support was ranked third after SATAP English test score and, in second place, school quintile. This perhaps should have been expected given that students who came from schools in quintiles 4 and 5 ($M = 65.67$, $SD = 12.60$) performed significantly better in the English SATAP test than students from schools in quintiles 1, 2 and 3 ($M = 58.14$, $SD = 13.87$), $t(68) = 2.37$, $p < 0.05$; albeit not a particularly large effect, $r = 0.27$ (two-tailed). This is reflected in the tree where those very few students who were granted access to the Programme, but had come from quintile

5 schools, performed very well in both the English SATAP test and in the Science Communication module.

What is perhaps also worth pointing out, given the theory emerging from the other modules so far described, is that those students who performed better in the maths selection test did not perform as well in Communication in Science as those who scored lower marks on this test (node 8, *M* = 57.68, *SD* = 4.04). Furthermore, those students who were compromised because they did not receive as much financial support (node 2) were adversely affected by the selection mechanism in place – those with better selection model scores did comparatively badly in this module (students in terminal node 6 scored the poorest of all student groups; *M* = 54.31, *SD* = 4.18).

When introduced to the construction of trees, the “M score” did not feature in either the 2008 or the 2009 trees; nor did matric score or “matric score equivalent”.

The inverse relationship between English language proficiency and the selection mechanism used to grant students access to the Programme is unmistakable. Student performance in the Communication in Science module might well be improved through financial support irrespective of how they perform in the selection process.

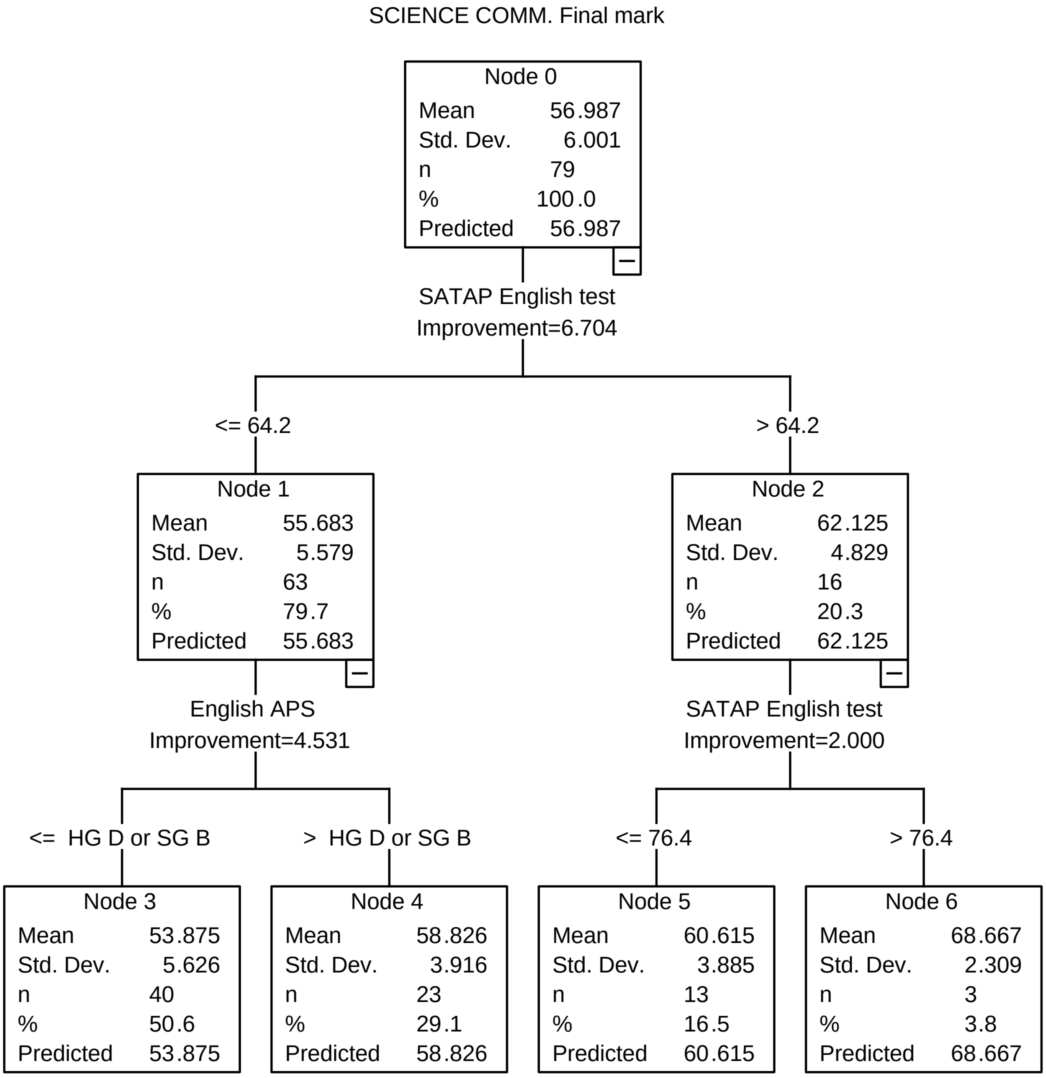


Figure 40. Regression tree for 2008 final marks for the Communication in Science module (*N* = 79*).*

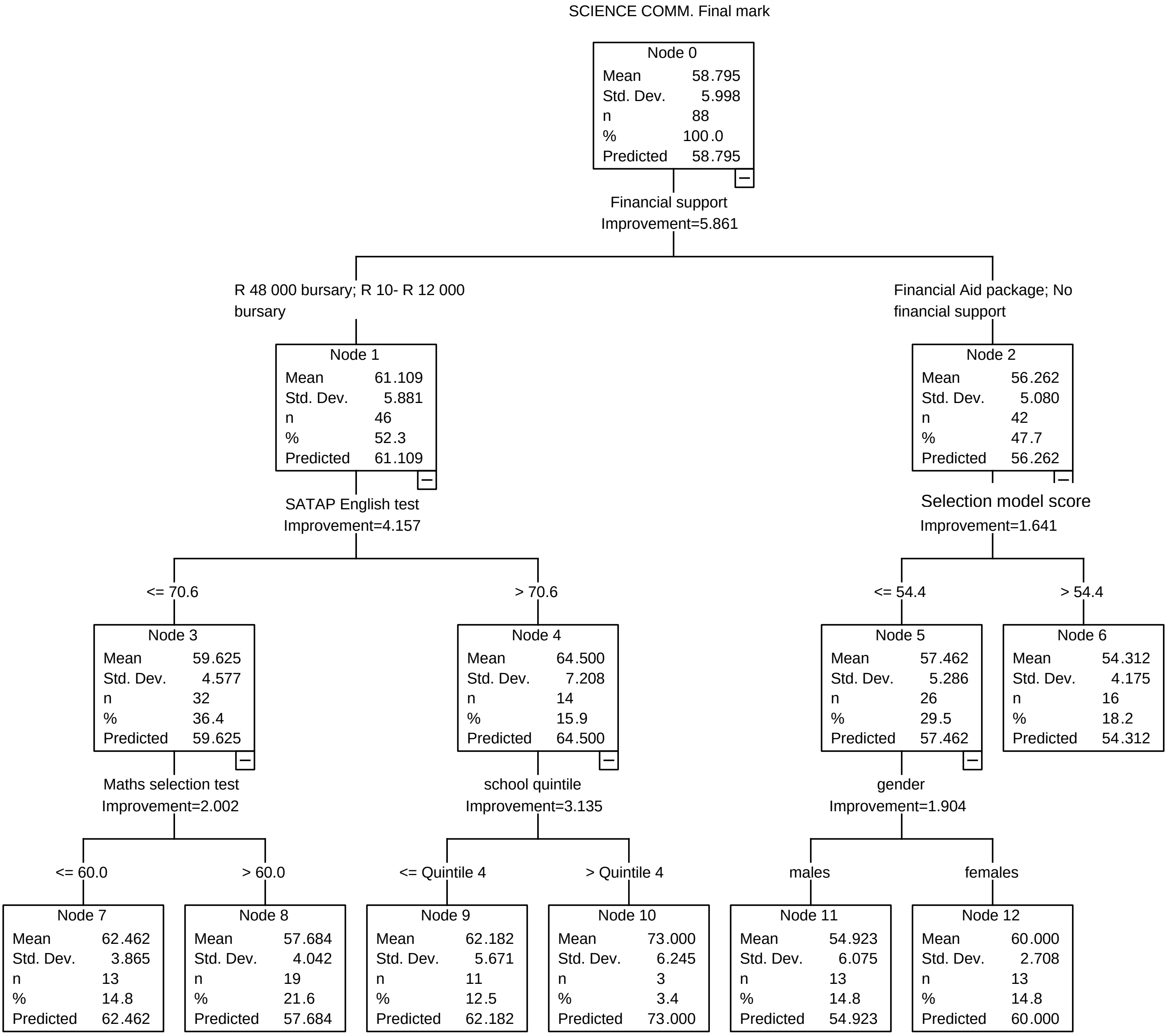


Figure 41. Regression tree for 2009 final marks for Communication in Science module ($N = 88$).

Student Performance in the Foundation Programme as Indicated by Overall Average

Overall student performance in 2008, as indicated by the mark calculated by taking an average of the final marks of all five foundation modules, can neatly be described by the selection model score (Figure 42). Homogeneity in the daughter nodes was increased by 30% by this one variable, for which the only reasonable surrogate to be found was school Physical Science APS (improvement in purity = 10.25, λ coefficient for contingency tables = 0.43). It appears that performance in school physical science has, in the past, been a fairly reliable indicator of potential to perform well in the Foundation Programme. Indeed, the influence of this school subject in 2008 has been noted in the Foundation Biology, Chemistry and Physics modules described above. This variable was ranked second to the selection model score in terms of overall importance in the construction of the tree, the third variable being English SATAP test scores, followed by, in fourth place, financial support. These latter two variables were not as effective as the "M score" in reducing heterogeneity in the root node (when "M score" was added to the tree-growing process); nonetheless "M score" was only half as good as the selection model score in improving purity in the nodes (improvement in purity = 8.68, λ coefficient for contingency tables = 0.54).

However, when testing the influence of the "M score" in the absence of the selection model score, this variable and English SATAP scores were shown to be the most important primary splitters, and ranked first and second in overall importance (Figure 43). The heterogeneity of node 1 was reduced by 36% by the "M score", with those achieving fewer than a score of 45 performing relatively poorly in the Foundation year (node 3, M = 51.83, SD = 5.17). Furthermore the maths selection test was revealed as an effective indicator of performance in the group of students who achieved more than a total of 45 points for their maths and science school subjects. In both trees (Figures 42 and 43), matric score was not revealed as an important indicator; only in the absence of the selection model score (Figure 43), matric score was revealed as a surrogate (albeit very poor) for the "M score", reducing the heterogeneity of node 1 in this tree by very little (improvement in purity = 3.74, λ coefficient for contingency tables = 0.42).

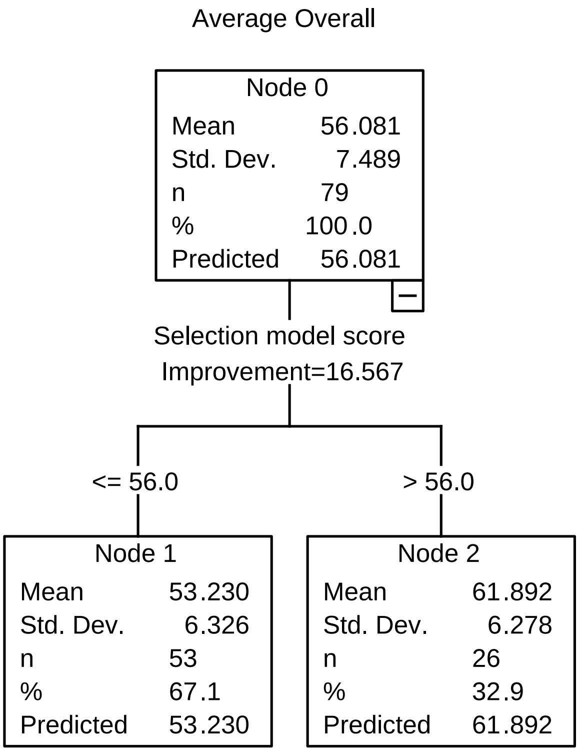


Figure 42. Regression tree for 2008 overall final mark average (*N* = 79).

In Figure 42, those students who achieved more than 56 points in the selection model score in 2008 did very well in the Foundation Programme in comparison to those who achieved this score or below (*M* = 61.89, *SD* = 6.28; *M* = 53.23, *SD* = 6.33 respectively), *t*(77) = 5.73, *p* < 0.001; this being a large effect as described by Field (2009), *r* = 0.57 (two-tailed). The influence of the selection model score is also seen in Figure 44 where it best explains the 2009 mainstream performance of the 2008 NSC students. Here, an even higher selection model score of 58 separates those students who achieved well in the Programme from those who only just passed (nodes 5 and 6). It is particularly important to note that the selection model score for automatic selection into the 2008 and 2009 Programme was 52 selection points. Furthermore, 32 % (in 2008) and 23% (in 2009) of those students admitted into the Programme did not actually achieve this score but were admitted anyway on other grounds. In fact, using the full suite of selection criteria, of which the selection model score is but one criterion (see Figure 30), only 27% and 15% received automatic acceptance into the Programme in 2008 and 2009 respectively, the balance failing some minimum criterion and being accepted later after consideration by the Faculty Officer for Science Access and the Dean of Faculty. As effective as the selection model score appears to be at identifying students with potential to succeed in the Programme, it is not being used to its full potential.

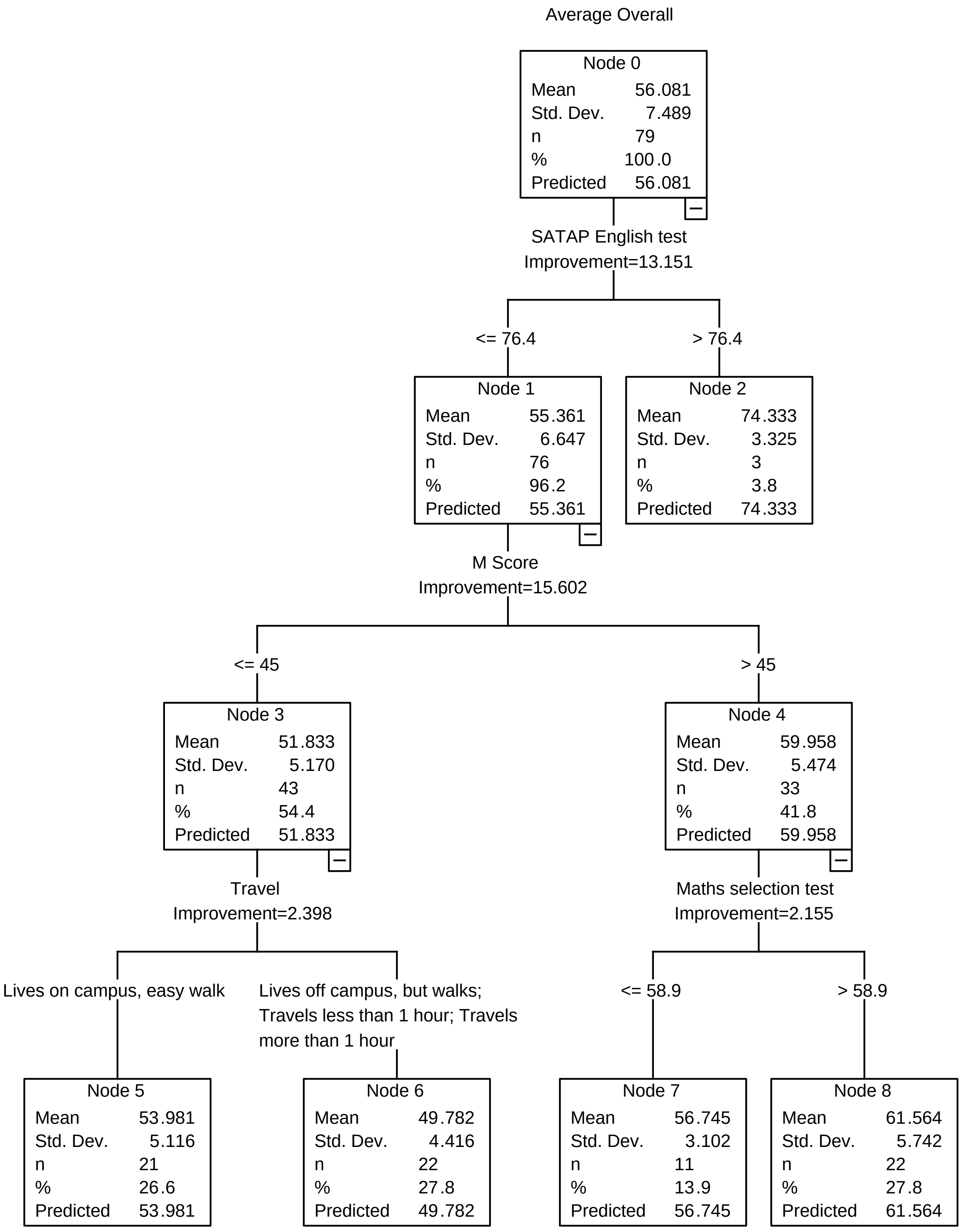


Figure 43. Regression tree for 2008 overall final mark average (*N* = 79). The selection model score has been replaced by constituent “M score” in tree construction.

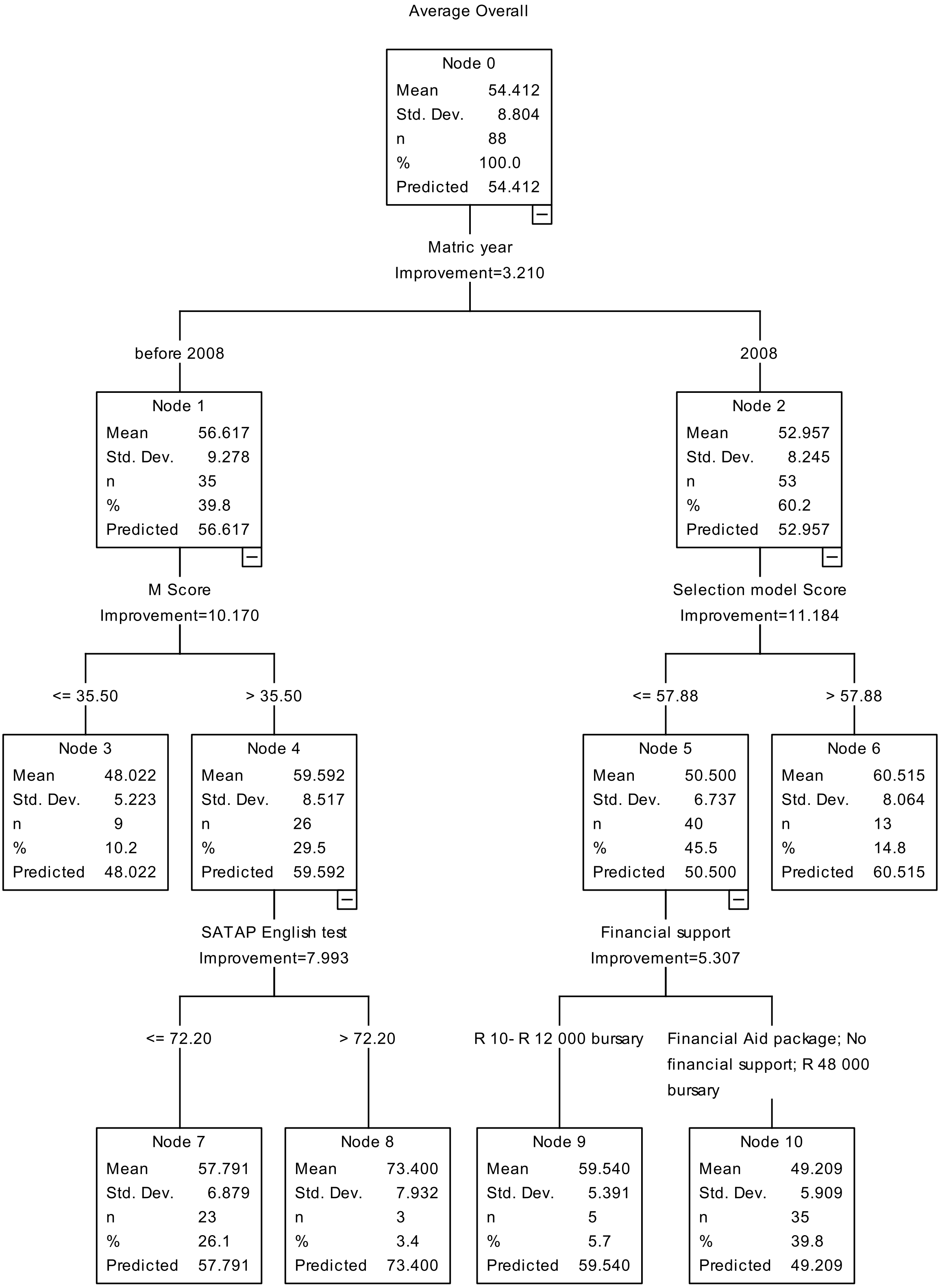


Figure 44. Regression tree for 2009 overall final mark average (*N* = 88). Schooling cohort forced as splitter of the root node. Matric scores and APS applicable to each schooling cohort (SC not made equivalent to NSC).

Figure 45 describes general trends in the 2009 cohort. This tree was constructed without distinguishing pre-NSC students from those who had completed the NSC (and therefore "equivalent APS" scores were used as for the 2009 individual module trees). The maths selection test, already alluded to a number of times, comes to the fore in this tree with the small group of overall best-performing students, having achieved more than 77% in this test (node 2). This variable was also ranked first in terms of overall tree construction, the selection model score dropping to second place, and found to be a reasonable surrogate for the maths selection test (improvement in purity = 10.56, λ coefficient for contingency tables = 0.6). Performance of the bulk of the student body (node 1) was subsequently distinguished by accommodation arrangements (this variable being ranked third most important in the overall construction of the tree). Together, the maths selection test and accommodation reduced heterogeneity of the root node by 34%. The "M score" was not revealed as a possible substitute for the maths selection test as primary splitter of the root node; not even when the selection model score was excluded from the list of variables.

However, the influence of the "M score" on the pre-NSC students is evident in Figure 44 (where "matric year" is forced as the splitter of the root node). For the 35 Senior Certificate students the "M score" would have been a good indicator of success (and this has been suggested in the 2008 tree above); not so for those students who had completed the NSC ("M score" improvement in purity = 4.15, λ coefficient for contingency tables = 0.31 as a surrogate for the selection model score as splitter of node 2). For those NSC students who achieved lower selection model scores, it is possible that large bursaries distract from achieving academic success (and no financial support is equally problematic) (node 10).

The role of higher levels of English language proficiency (as indicated by the English SATAP test scores) on performance is reiterated in both Figures 44 and 45. Conversely, there is no evidence to suggest that the science selection test (on its own) was at all useful in explaining overall performance (or performance in any of the Foundation modules), and its use in the future as a component of the selection model score needs to be examined. Matric score (or matric score equivalent) also had very little importance in the construction of any of these trees. In using only this variable to construct a tree, an inverse relationship between performance and, in particular the NSC matric score, was found for some students; for others, a better NSC matric mark meant better Foundation Programme performance. This is significant since the admission to the Programme is dependent on this score (Chapter 1, Table 3 and Chapter 8, Figure 30).

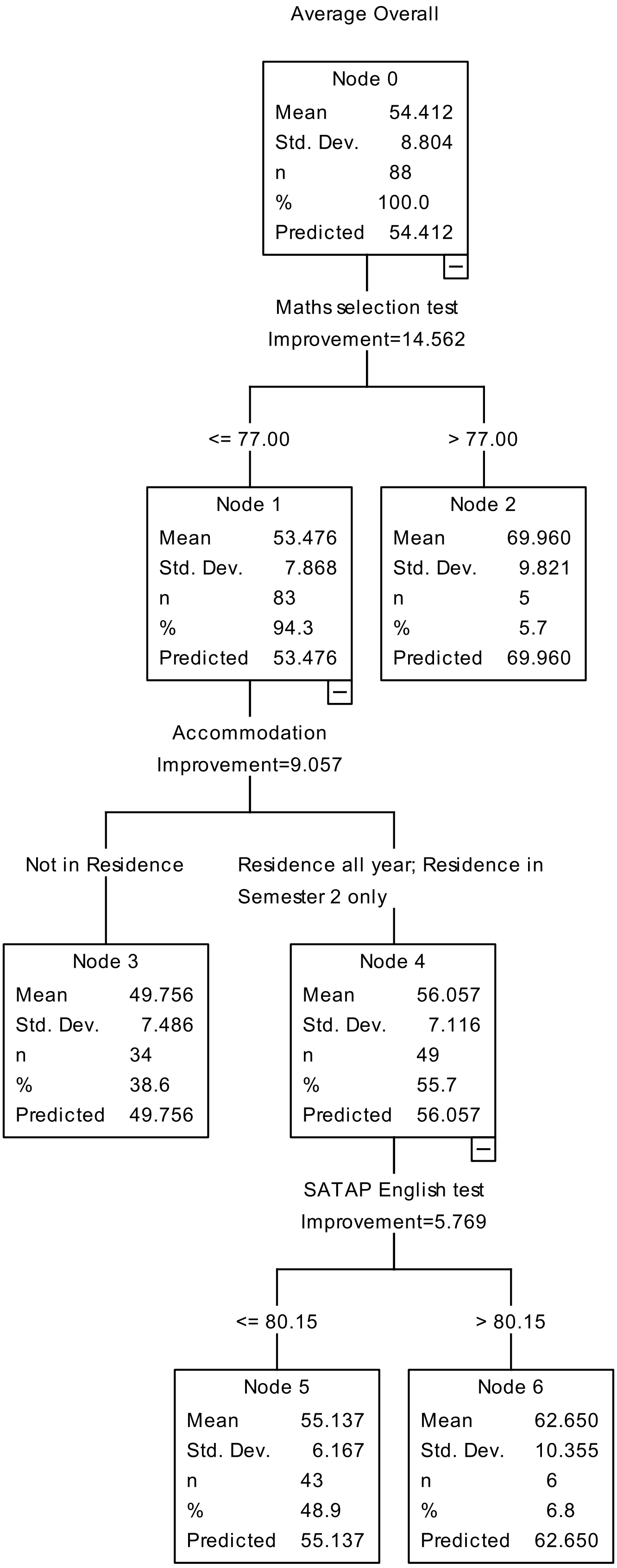


Figure 45. Regression tree for 2009 overall final mark average (*N* = 88). Students **not** distinguished by schooling cohort with a forced root node split.

Given the explanation of overall student performance as described by these trees, it is not surprising that it was possible to fairly accurately predict student performance in 2009 using only the selection model score to generate the rules for tree construction (Appendix R) (r = 0.45, p < 0.01), this being considered a medium to large effect (Field, 2009). The isolated "M score", in conjunction with the individual English SATAP and maths selection test scores was shown however, to have no value in predicting the 2009 average mark (predicted and actual average mark for 2009, r = 0.02, p < 0.05).

With the reiteration of the dominance of the selection model score across the "hard science" Foundation modules, and as a predictor of overall performance across all five modules, it is clear that the selection model score has great value in determining whether a prospective student has potential to succeed in the Foundation Programme or not. Clearly though this model has not been used to its best potential to ensure success after access, as the students have to date been accepted with scores much lower than 56, the score repeatedly shown to have better prognostic value.

Whilst it may have been possible in the past to use the Senior Certificate "M score" as an indicator of potential, the value of this score on its own diminished in 2009. The Foundation Biology module is an exception to this rule.

By comparison, the maths selection test, as a component of the selection model score appears to have increasingly more prognostic value; this appears not to be the case with the science selection test. Having excluded the possibility that the SATAP English test could be included in the selection mechanism (for indeed, some students who have potential in Mathematics and Physics at least, would not be granted access to the Programme on this basis), attention must turn to devising an alternative selection model that possibly excludes the costly science selection test.

It would also appear that students selected on the basis of their potential as indicated by the selection mechanism, may not necessarily excel in Foundation Biology. Since the selection mechanism disfavours the Foundation Biology module, there is no option but to prioritise remediation in English language proficiency in the Biology module curriculum.

Given the iteration also of the increasingly important role accommodation and financial support play in the success of 2008 and 2009 students, the mechanisms allowing access to these students should be extended to these socio-economic issues. This is particularly true of those students who enter already at risk since their academic performance, to date, has been shown to be weaker.

Student Performance in the Foundation Programme as indicated by Proceed Decision

The classification trees generated for the proceed decision in 2008 and 2009 are similar in number of respects. Most striking is the role played by accommodation; none of the students who rented accommodation in 2008 passed the year (Figure 46), and 25 of the 35 students without a place in residence in 2009 did not proceed (Figure 47, node 1). The Gini indices of impurity of the root nodes were reduced by this variable by 22.5% and 14% in 2008 and 2009 respectively. For those students who did have a place in a University residence (or in 2008, lived at home), the selection model score was a very important indicator of their ability to pass the Programme. In both cohorts, the cut-off value to best ensure a student proceeded was 50.8 (51) selection model points. A total of only three students who achieved less than this score (and had more secure accommodation) passed the Programme over the two-year period (Figure 46, node 3). Of those in University residence in 2009, none who achieved less than this score, proceeded from the Programme (Figure 47, node 3). Figure 48 explores the influence of the schooling system on this relationship between the selection model score and accommodation arrangements in 2009: although the year of matriculation did not appear to be particularly important for success in the Foundation year, the issue of accommodation took precedence over the selection model score for those students who had written the NSC examinations (node 5 shows that those students not provided with secure accommodation perform particularly badly).

Indeed, although accommodation was the primary splitter of the root nodes in Figures 46 and 47, it was the selection model score in 2008 and 2009 that was ranked first in terms of overall tree construction, with accommodation in second position in both instances (74.6% and 50.5% relative normalized importance in 2008 and 2009 respectively). This is an indication of the increasing importance of the selection model score for those students given a fair chance of succeeding by virtue of the fact they had secure accommodation, and particularly for those who had written the NSC (see also Figure 48, node 6).

In particular, the maths selection test component of the selection model score had increasing value. In 2009, this selection test was revealed as a better surrogate for the selection model score than the isolated “M score” (improvement in purity = 0.032, λ coefficient for contingency tables = 0.50; improvement in purity = 0.021, λ coefficient for contingency tables = 0.33 respectively). (In 2008, these components had equal value as surrogates for the selection model score.) This is reinforced by Figure 48. Whilst the "M Score" is a very good surrogate for the selection model score of those students who had written the Senior Certificate (node 1, improvement in purity = 0.052, λ coefficient for contingency tables = 0.71), this is not so for those students who had written the NSC (node 6). Here, the "M score" was not a possible surrogate at all for the selection model score with the maths selection test being the best surrogate instead (improvement in purity = 0.029, λ coefficient for contingency tables = 0.75). Furthermore, the selection model score was able to reduce heterogeneity in the 2009 root node (Figure 47) almost as well as accommodation (improvement in purity = 0.059) (again, this was not so in 2008).

An inference to be drawn here is that careful selection of those students leaving school with a National Senior Certificate is increasingly important. This has also been suggested by Nel and Kistner (2009) whose research indicated that grade inflation had occurred in the 2008 matriculant results, particularly in lower performing students, and in the mathematics results. Given their concerns, they recommend that universities give serious consideration to the use of additional measuring instruments for student admission (especially in respect of mathematics), in conjunction with matriculation results.

Once selected on the basis of some alternative selection mechanism, providing a place in residence will improve that student's chances of proceeding from the Programme considerably. Indeed, accommodation has long been recognised to have an impact on the affective needs of students. Barnsley and Liebenberg (2000b) cite Newton (1998) by pointing out that the provision of supportive living units is most important in the building of supportive, inclusive communities that students need and desire. Vosloo and Blignaut (2010) have also demonstrated the benefits of secure accommodation in the South African context. The issue of inadequate university student housing has been acknowledged by the South African government as described in the popular media (Dibetle, 2009), and Barnsley (2008b, 2010) reports a shortage of student housing on the Pietermaritzburg campus of UKZN specifically. Tinto (2005) makes the distinction between "persistence" – associated with student characteristics and desires, and "retention" – referring to institutional actions and responsibilities. Clearly, the provision of suitable accommodation speaks to the latter in terms of ensuring better throughput for the Foundation Programme.

This approach is aligned with the work of Boughey (2007) who also argues for institutions of higher learning to take cognizance of students' socio-economic realities when considering options available for institutional responsiveness at a systemic level. This view, born of a "historical-structural" understanding of "disadvantage", reorientates perspectives of deficiency to the structures that act on individuals and away from individuals themselves (ibid, p.8).

The effect of implementing the level 4 English requirement in 2009 is also apparent in the trees. In 2008, prior to this being an admission requirement, English APS was the primary splitter of node 4 (Figure 46), that is the bulk of students who stood a reasonable chance of proceeding since they had been given a place in residence and had achieved at least 51 points in the selection model. Only 2 students with higher levels of English language proficiency did not proceed (node 6). In 2009, English language proficiency did not feature as a primary splitter and ranked low in terms of relative importance in overall tree construction (ninth and eleventh out of 19 variables for English APS and English SATAP test respectively, Figure 48). This reiterates continuous non-alignment of potential to perform well in Biology module with overall success in the Programme. Instead in 2009, the influence of performance in school physical science was apparent, with almost all students in node 6 achieving more than a minimum of level 2 (or equivalent) in this subject, going on to proceed from the Programme. Although this variable had a relatively small effect on proceed rates in comparison to the selection model score (23% relative importance), in context of its role in explaining overall average Foundation marks (as suggested earlier), it appears that, of all the school subjects included in this analysis, physical science is the most reliable.

A troubling inverse relationship between the science selection test and performance was found in 2008 proceed/ exclude tree (Figure 46, nodes 9 and 10) with those students not scoring well in this test going on to proceed from the Programme and vice versa. This selection test did not feature in the 2009 tree as a primary splitter or reasonable surrogate for any split.

In none of the trees was matric score (neither the Senior Certificate nor the NSC) indicated as a useful descriptor of performance; this variable did not appear as a viable surrogate for the selection model score in both Foundation years. This is in contrast to the findings earlier in Chapters 6 and 7 where the NSC matric in particular was found to be a reliable indicator of success in mainstream; clearly this score can not be used for admissions with any degree of reliability at the lower end of the performance range, i.e. for those students better suited for Access programmes. These findings are in contrast to other South African research that has found the Senior Certificate matric results to add to the predictive validity of the aptitude tests used for selection into an access programme (Van der Flier et al., 2003).

Although actual numbers are reflected in these trees, they may also be interpreted in terms of predictive value. The grey highlighted bands in each node serves as an indication of what would be predicted were the trees to be used for predictive purposes. For example, the 2009 model would predict that **all** students not provided with a place in residence would not proceed. Both the 2008 and 2009 trees had good predictive power: 87.3% and 80.7% respectively. In other words ten students (12.7%) would have been misclassified by the 2008 tree: of the 44 students that proceeded, five would have been predicted to fail (88.6% would have been correctly predicted). Similarly, of the 35 who did not proceed in 2008, five would have been predicted to proceed (85.7% correctly predicted). The 2009 model was found to have slightly less predictive power. Of the 43 students who did not proceed that year, the model would have incorrectly selected seven who that would have passed (83.7% of not-proceeds correct). Ten of those who did actually pass would have been predicted to fail (22.2% incorrectly predicted).

The ability of these models to ***explain*** *proceed rates is very clear; moreover their ability to* ***predict*** *failure and success is considerable, given the low degree of misclassification as described above. No single school history indicator of potential to successfully proceed from the Foundation Programme appears to exist; furthermore the composite school science and maths scores are insufficient. Combined with alternative selection tests however, school maths and science performance acts as a powerful selection tool that efficiently discriminates between those students who have the potential to proceed from the Programme, and those who do not. With this confirmed, it would be foolhardy to accept students into the Programme with less than the minimum prescribed selection model point score. To maximise the power of this selection tool, the selection model formula must be refined in view of excluding the apparently superfluous science selection test. Once granted access to the Programme, it appears that success can be better ensured by accommodating them in University residence.*

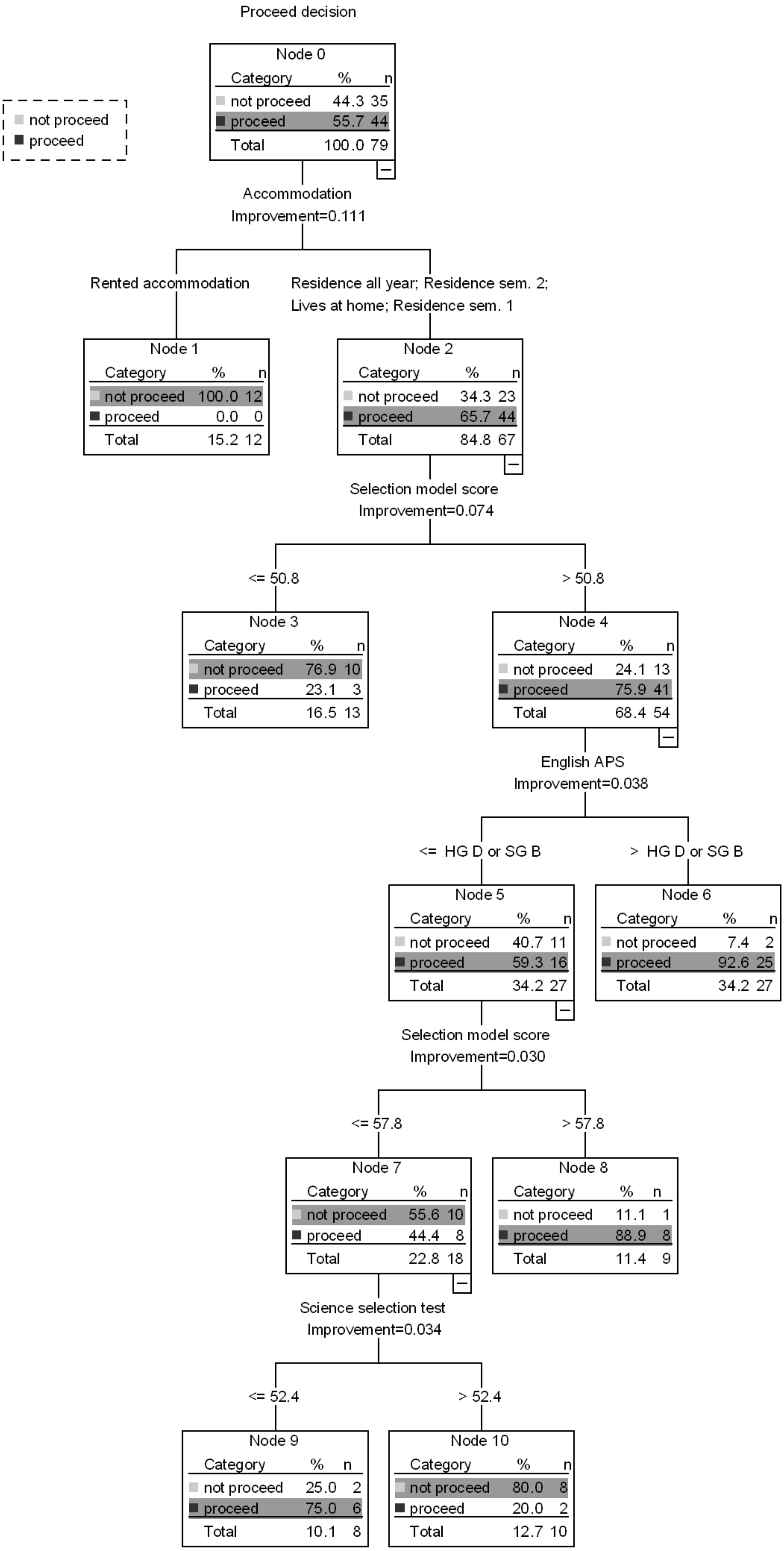


Figure 46. Classification tree for 2008 proceed decision (*N* = 79).

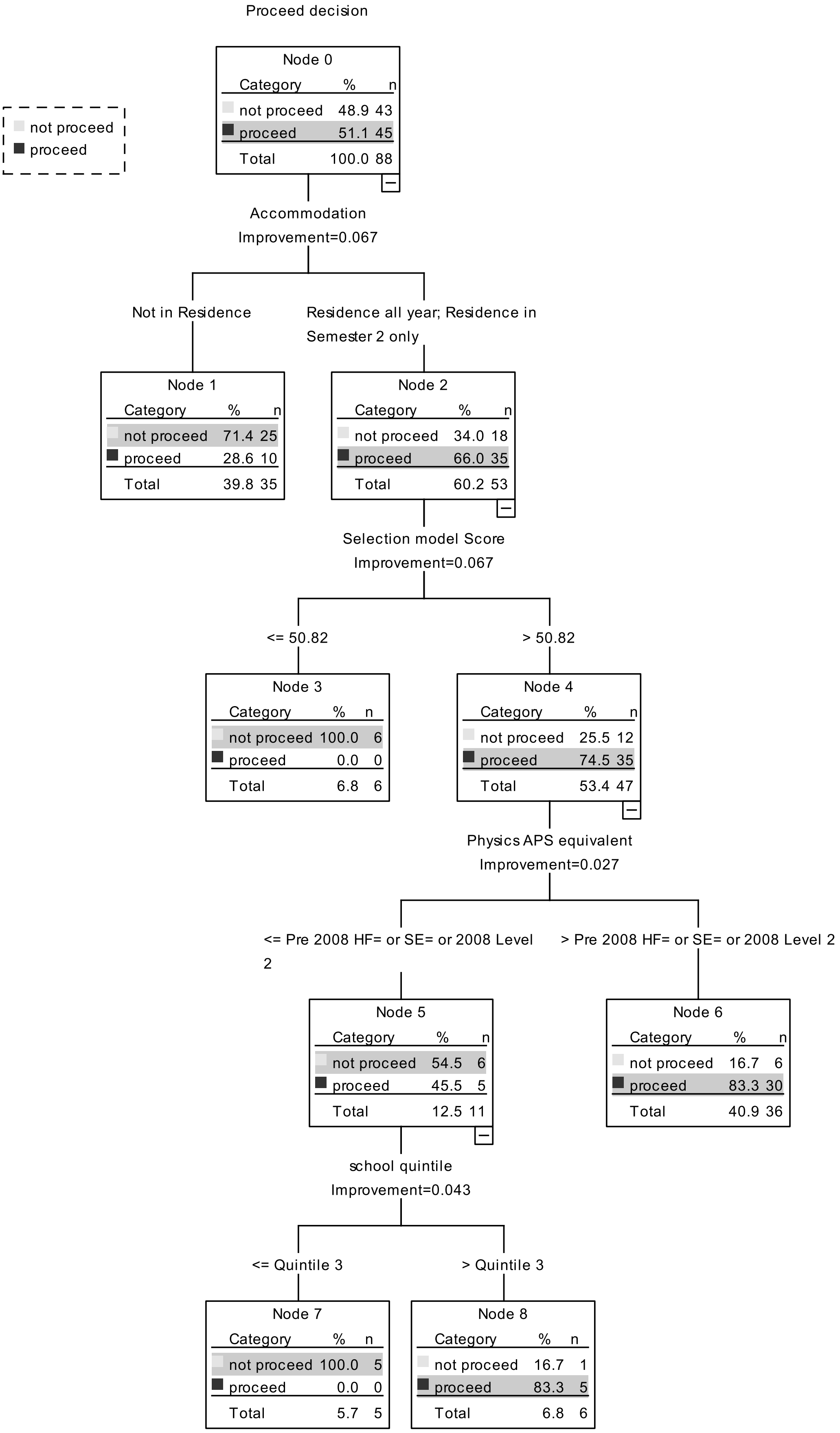


Figure 47. Classification tree for 2009 proceed decision (*N* = 88). Matric scores and school subject APS for SC students made equivalent to NSC students.

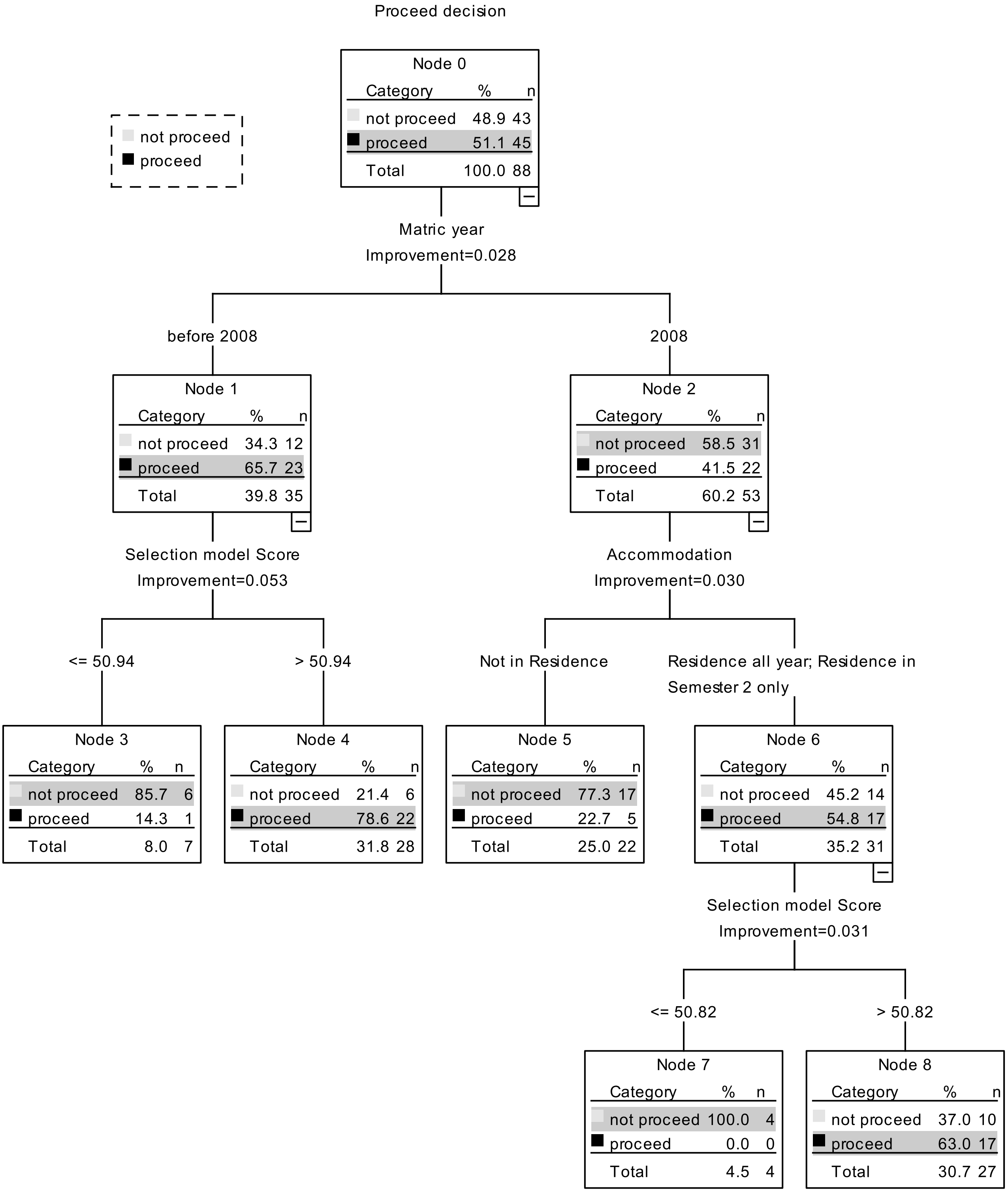


Figure 48: Classification tree for 2009 proceed decision (*N* = 88). Matric scores and school subject APS for SC students are not made equivalent to NSC students; each score pertinent to year of matriculation.

A Synopsis of Key Findings Related to Foundation Student Performance as the Basis for the Emergence of Grounded Theory

The following synopsis of Foundation student performance recorded in this and the preceding four chapters is intended to highlight the most salient findings which have contributed to the emergent grounded theory. This theory will be taken forward in the final chapter as the basis for exploring opportunities for remediation in the Foundation Programme.

Performance of the Foundation students in mainstream. An examination of the performance of access students relative to direct entry students in a first-year biology module found that Foundation students outperformed the Augmented students, performed as well as, or better than their direct access English Second Language counterparts, and in some instances, performed as well as the direct access English First Language students.

In being selected into mainstream after successfully completing the Foundation Programme, and been successful in mainstream, the Foundation student performance has given evidence that UKZN's objectives of equity and effectiveness are being met.

An examination of students' final marks in the mainstream BIOL 101 module revealed that English language proficiency had particular influence on student performance. Only above a certain level of English proficiency (as indicated by school performance in English) were students advantaged in mainstream by having achieved higher admission point scores on entering university.

Those students not "advantaged" by higher levels of English language proficiency were identified as being advantaged by having done the Foundation Programme in their Access year. Others, who had in the past been admitted directly to mainstream on the basis of their performance in matric, but who had lower levels of English proficiency were identified as candidates who would have benefited by accessing mainstream via the Foundation Programme. It was proposed that this would necessitate a review of the Science Faculty's admission's criteria to allow such students to enter the university via alternative access routes. An additional proposal discussed was that fundamental restructuring of foundational provision within the context of the mainstream Life Science Biology module be considered, and this module's relationship with Access and academic development within the Faculty’s programmes as a whole be reviewed. The widening of Access at UKZN could thus be facilitated.

However, with English language proficiency shown to be a limiting factor for the majority of students in the mainstream module investigated (irrespective of year of matriculation, ethnicity or access route to mainstream), it was proposed that the explicit inclusion of an academic (language) literacy component (which specifically addresses the fundamentals of reading and writing) in the curriculum seriously be considered.

Having established that the Foundation Programme had indeed been an effective mechanism for enabling mainstream epistemic access to students who had succeeded in their Foundation year, but cognisant that the challenge of English language proficiency remained, this issue, and a compendium of additional factors that could help explain student performance in their access year, was then explored. Insight gained contributed to an understanding of Foundation student performance aimed at identifying possible opportunities for remediation in the existing Programme to maximise student potential, and their preparedness for successive Biology modules. In addition, in attempting to ensure a selection process that could enable access to the disadvantaged student whilst simultaneously ensure a measure of success, the fairness and effectiveness of the mechanism of selection into the Programme could be evaluated.

Performance in the Foundation Biology module. The variables that distinguished the better performing students from those that struggled with Foundation Biology pertained to their English language proficiency (as reflected by student’s school English performance and, in particular, the SATAP test scores). There were no strong surrogates for these indicators of performance.

The selection model score played no role in determining performance in this module. Matric score, performance in school maths and in the selection science test also had very little influence over performance in Foundation Biology. However, unlike the “hard sciences”, “M score” was found to be a good indicator of success in the Foundation Biology module in both 2008 and 2009. Generally, whether students had studied Biology at school or not was unimportant; had students done this subject at school it had less of an impact on their performance in this module than English language proficiency or their “M score”.

The motivation score was found to contribute little to the understanding of performance in Foundation Biology, although in 2008 there was a suggestion that higher general motivation scores were associated with better performance if students were not particularly weak in more than one subject area. Attempts to reveal possible hidden elements of motivation that might be more helpful in describing student performance, revealed only the "competition score" as having any value (albeit minimal). Only the weakest of the entire cohort had high "competition scores", the remaining students were generally unmotivated.

Accommodation in the University residence had a small positive role to play in ensuring success in the Foundation Biology module.

As in Foundation Biology, English language proficiency was the primary influence on student performance in the Foundation Communication in Science module. The influence of financial support on performance in this module was also unmistakable, particularly in 2009.

Performance in the "hard science" modules. The selection model score, and in particular the maths selection test component thereof in 2009, was revealed as the most influential variable in explaining student performance in Foundation Mathematics. Similarly, for the Foundation Physics module, the selection model score was unequaled in its ability to explain student performance in both cohorts. Indeed the selection model score distinguishing better students from those who were borderline was the same for Physics as it was for Chemistry in 2009, i.e. 57.

In isolation, the "M score" component of the selection model score was not an effective indicator of success in either the Mathematics, Chemistry or Physics modules. In addition, Matric score (or "matric score equivalent") had almost no influence on performance in the Foundation Chemistry, Maths or Physics modules.

Inverse relationships in performance in both the Foundation Maths and Physics modules and English language proficiency (and school Biology/ Life Sciences in the case of Foundation Physics) were found to exist. For those stronger Biology students who also had higher levels of English language proficiency, this effect was compounded, associated with their failure in the Physics modules in 2009.

English language proficiency however, played a greater discriminatory role in Chemistry than in the other “hard sciences”, with higher English SATAP test results having a positive influence on student performance in the Chemistry module. Although access to, and success in, the Biology and Chemistry Foundation modules were clearly not contingent on the same factors, there was a commonality of the peripheral influence of the English SATAP test results.

The influence of financial support on performance in the Foundation Mathematics and Chemistry modules was clearly evident, as was accommodation in the former (as indicated by the relationship with its proxy variable, travel arrangements), and to a lesser extent in the latter. Students having to live in rented accommodation performed poorly in Foundation Mathematics. Similarly, the provision of secure accommodation on campus was found to be of particular importance in ensuring success in the Physics module in 2009. Certainly within the group of students who achieved lower selection model scores in this cohort, this factor was crucial, with those students not in residence failing the Foundation Physics module.

Performance as indicated by overall average and proceed decision. Student performance in 2008 as indicated by overall average of the final marks of all five foundation modules, was neatly described by the selection model score, the suggested cut-off for success was 56 points. Similarly for those NSC students in the 2009 cohort, the selection model score (at 58 points) was shown to be the most effective variable in discerning students with higher overall averages from those who only just passed with 50%. These suggested cut-off selection model values are higher than those implemented in practice (if indeed, the measure was used at all). As effective as the selection model score was in identifying students with potential to succeed in the Programme, it is apparent that this tool was not being used to its full potential.

In 2008 and 2009 accommodation played a primary role in the proceed rate of Foundation students (and in determining their overall average in 2009). For those students accommodated in a University residence the selection model score was the most important indicator of their ability to pass the Programme (the cut-off value in this context set at 51 for both cohorts). For those students who had written the NSC, the provision of accommodation on campus was of particular importance in ensuring successful progression from the Programme; similarly for those students who had written the NSC, the selection model score was particularly effective at discerning success from failure to pass the Programme.

In addition, the maths selection test component of the selection model score was found to have greater value in the selection of students from the NSC relative to those who had written the Senior Certificate; by contrast, the “M Score’ was found to have decreasing value. (The “M score” had greater discriminatory power in the Senior Certificate than in the NSC).

The science selection test was found to have no value as a component of the model for selection (as indicated by proceed rate) and a very unreliable indicator of overall average. (For some NSC students an inverse relationship between performance and NSC matric score was found to exist).

Matric score was not indicated as a useful descriptor of Foundation student performance (as measured by overall average or proceed decision). This is in contrast to the role this variable (particularly the NSC) plays in reliably explaining mainstream student performance; clearly this score can not be used for admissions with any degree of reliability at the lower end of the performance range, i.e. for those students better suited for Access programmes.

English language proficiency was found to be relatively unimportant in ensuring progression from the Programme (and was effective in discerning high overall Foundation averages in only the very few students with particularly high English marks); this reiterates the non-alignment of potential to perform well in the Biology module with overall success in the Programme.

The seminal findings presented above, and the emergent grounded theory refined below, have been made through the employment of a methodology that has relied extensively on quantitative data collection and analysis. Whilst the methodology has enabled recommendations to be made upon generalized trends, and has therefore been highly effective in achieving the major objectives of this research, no qualitative data collection has been conducted. It is acknowledged that the lack of depth typically facilitated by qualitative data is a limitation of this study. Future studies that interview students in Science Access Programmes, and in mainstream, to gain deeper perspectives would indeed be fruitful, and are worth serious consideration.

Refined substantive grounded theory emergent from the research findings:

Foundation students in mainstream first year Biology at UKZN may be considered "the advantaged disadvantaged". Despite the advantages gained by the completion of an access year, opportunities exist for remedial action that will further promote epistemic access and student success. Ongoing review and revision of the Foundation Programme is necessary to ensure opportunities for remediation of practice are recognised.

Provided that Foundation students are given a fair chance at succeeding in their studies through the provision of socio-economic support in the form of places in university residence and financial assistance, the selection model score can be taken as an increasingly powerful tool that efficiently discriminates between those students who have the potential to proceed from the Programme, and those who do not. Moreover careful selection of those students leaving school with a National Senior Certificate is increasingly important. This requires recognition that the selection model has not been utilized to its full potential to facilitate student success after formal access. This also necessitates an interrogation of the selection model components, and recognition that school maths and science performance is only indicative of future success in the Foundation Programme when combined with an alternative selection mathematics test.

Whilst it may have been possible in the past to use the Senior Certificate "M score" as an indicator of potential to succeed in the Foundation Programme as a whole, the value of this score on its own has diminished with the introduction of the NSC matriculation system. Futhermore, this "M Score" and English language proficiency had little value in determining success in the "hard science" foundation modules. By contrast, the effect of English language proficiency (and the "M score" to a less extent) on the performance in the Foundation Biology module is considerable. Similarly, English language proficiency most clearly determines performance in the Communication in Science modules.

Thus students selected on the basis of their potential as indicated by the selection mechanism (a valuable indicator of overall success in the Programme) may not necessarily excel in Foundation Biology or the Communication Science modules. The unmistakable inverse relationship between English language proficiency and the selection model score indicates that the CSA selection mechanism disfavours the Foundation Biology module. This places greater pressure on the Foundation Biology module than on *the "hard science" modules in terms of facilitating student success after granting formal access to the Programme. Undeniably the inclusion of a measure of English language proficiency in the selection tool is not an option. Remediation in English language proficiency within the Biology module curriculum is thus a priority if epistemic access is to be facilitated in this module in order to best aid successful progression from the Programme and support retention in mainstream thereafter.*

CHAPTER 10

Factors Influencing Performance of Foundation Programme Students

Reflection, Taking the Grounded Theory Forward and Opportunities for Remediation

As already mentioned, Zaaiman et al. (2000) have stressed the importance of fair, effective and efficient processes for selection into Access programmes. The main aim obviously in these processes is to reduce the number of "false positives" (those selected students who do not pass) whilst minimising the "false negatives" (rejecting students who would have been able to pass) as the social and financial costs of selecting the wrong students are high. Indeed, to knowingly admit students who have no chance of academic success is immoral (see also Fraser & Killen, 2003).

Bartram (1995) (also cited by Zaaiman et al. (2000) claims that factors that improve a selection mechanism include predictive validity, top-down selection (as opposed to selecting at random above a particular cut-off point) and a large, applicant pool. Clearly the Foundation Programme selection model formula used is effective in identifying students with the potential to succeed in the Foundation Programme as a whole, and in the Foundation Physics, Chemistry and Maths modules. However, as demonstrated, it has little, if any, predictive validity for the Foundation Biology module. Overall performance in this module has been shown to be affected considerably by English language proficiency, and despite the advantages successful Foundation students have over other English Second Language students in mainstream, this factor continues to influence their performance when they continue with their Life Science studies. This requires a response.

Also indicated, is the need to reformulate the selection model. This needs to be done in an environment where the applicant pool has reduced considerably (see Chapter 7) and where, at UKZN, students are admitted into the augmented stream or directly into the mainstream modules as they have the minimum entry scores for these programmes (although as Chapter 5, 6 and 7 have indicated, many of these students might have benefited by completing the foundation year before registering for first-year modules). Indeed, changes in selection criteria into mainstream, could well lead to an increase in the size of the applicant pool for the Foundation streams of Access.

Thus, in terms of multi-level responsiveness (a nuanced position to admissions that include alternative selection tools, and a restructuring of the learning environment), this study echoes the call of others in the South African tertiary education sector (e.g. Collier-Reed et al., 2010). As Zaaiman et al. (2000) suggest, the main responsibility for the development of a selection mechanism: "should preferably rest with the staff members who teach the courses for which selection is being done" (p. 19).

The Selection Mechanism

Widening the Foundation selection pool. The widening of the body of students to whom foundational access could be extended has already been discussed in some detail in Chapter 7. This was in context of the better performance in a high-impact mainstream module, of the Foundation students relative to direct access English Second Language students and those in the augmented stream. Lending additional support to this notion of increasing the selection pool is the finding that, in 2009, in terms of overall Foundation mark, those students who had met the augmented stream requirements, but completed the Foundation Programme[16], performed no better than those students who had met the foundation stream requirements only (M =53.2, SE = 1.13; M =55.83, SE = 1.53 respectively; $t(86) = 0.16$, NS, (two-tailed)). This represents a very small effect, $r = 0.15$.

However, there was a significant association between whether students had met the requirements for the augmented stream or not, and whether they proceeded from the Foundation Programme or not, $\chi 2$ (1) = 4.632), p <0.05. Of those foundation students that did **not** meet the augmented stream requirements (N = 41), 63.4% proceeded from the Programme. Of those foundation students that did meet the augmented stream requirements, (N = 47), only 40.4% proceeded. Based on the odds ratio, the odds of a student proceeding are 2.54 times higher if they did not meet the augmented stream requirements!

This, and the finding that the matric score has no explanatory or predictive value at the lower ends of the performance range, also lends support to a revision of the matric score as an admissions criterion for Access. This alone would radically increase the selection pool for the Foundation Programme.

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16. In 2009 a large number of Access applicants met the augmented stream entry requirements although there were very few applicants who met the requirements for entry to the Foundation programme. A decision was taken in January of that year to fill the augmented stream first and then to offer the extra students from the augmented cohort places in the Foundation programme (CSA, 2009).

Devising a New Selection Model Formula for the Foundation Programme. Widening of the selection pool also has implications for use of the selection model. As has been indicated, the current selection model is most effective in identifying students with the potential to succeed in the Foundation Programme as indicated by average final mark (and impacts heavily on whether students proceed from the Programme or not). However, as has been pointed out in the previous chapter, the number of students accepted who actually achieve the minimum selection model score is limited, and students are admitted on other grounds. The selection pool appears to be too small for the selection model to reach its potential. Although Fraser & Killen (2003) have pointed out that the selection of cut-off points is more related to supply and demand than it is to predictive validity in terms of potential success, this study suggests that the implementation of cut-off points has a moral value as they help to achieve an optimal fit between the level of preparation of the selected students who stand any chance at all of passing their access year and the teaching programme of the CSA at UKZN designed to guide and support their epistemic access to higher education. In Vygotskian terms, the selection model score appears to be a good gauge of students' zones of proximal development.

No doubt though, this selection model score can be improved. In contrast to the study by Zaaiman et al. (2000) who found that the average maths and science selection test score had good predictive validity for UNIFY students' final marks, the UKZN science selection test has been shown to contribute little positive value to the selection model score.

In addition, using multiple regression analysis, an English language proficiency test significantly improved the predictive validity of the UNIFY selection test battery (Zaaiman et al., 2000). On this basis, English proficiency tests were included in the selection mechanism to this Access Programme. It was acknowledged however that the inclusion of the English proficiency test, which was an open-ended questionnaire, reduced the efficiency of the selection mechanism since these tests were labour intensive to mark. Consequently a cut-off score for the maths and science selection tests was used to set a minimum cut-off value, and those applicants who achieved this were then assessed for the basic English proficiency required. This strategy was also expected to prevent students with high English language proficiency, but poor maths and science aptitude from being selected. Zaaiman (1998) had also previously shown that students with higher English language proficiency came from less disadvantaged backgrounds and it was thus expected that giving the English proficiency test the same selection status as the maths and science would be unfair to the more disadvantaged students. Selection in the UNIFY programme was then done by ranking according to the predictor that included English language proficiency of all those applicants who had achieved the required minimum in the maths and science selection scores.

Wood and Lithauer (2005) have also reported that the selection battery for testing applicants to the foundation programme at the Nelson Mandela Metropolitan University included an English language proficiency test. Stephens et al. (2004) has called for points to be awarded to English Second Language marks at matriculation level, and the National Benchmark (NBT) Academic Literacy test which focuses on testing higher education-level English literacy (Hurst, 2010), is currently being researched as an alternative admissions criterion for South African higher education institutions.

However for selection into the CSA Foundation Programme at UKZN it has been seen that the selection model score has dominated as a predictor across the “hard science” Foundation modules and for overall performance in the Programme (as indicated by an average mark). Performance in the Foundation Biology module alone is influenced primarily by English language proficiency. And indeed, an inverse relationship between language proficiency (and performance in the Science Communication module) and performance in Foundation Maths and Physics in particular, has been detected. Furthermore, with the implementation of the NSC level 4 English as an admissions criterion, the influence of this factor on a students’ ability to successfully proceed from the programme has diminished. Thus the selection model should not include performance in the SATAP English test.

It has also been demonstrated in Chapter 9 that the “M score” component of the selection model needs support from the maths selection test to become a useful indicator of potential. Furthermore, this score on its own has diminishing predictive value.

With the above in mind, possible new selection model formulae were devised using stepwise linear regression. The outcome variable used to generate the model was overall average mark rather than proceed/exclude status because of the relatively large influence of accommodation on the latter (and thus the inherent problems of identifying significant variables via regression modeling for inclusion in the formula).

Initially, a new selection model formula devised through regression using the 2008 cohort, that would allow for exclusion of the science test, and improve value in explaining performance in the 2008 average overall mark, could not be found without the addition of the English SATAP test results. This new formula (25.41 + 0.29 ("M score") + 0.19 (maths selection test score) + 0.12 (SATAP English)) was found, however, to explain both the overall average mark and the proceed/exclude decision at the end of 2008 better than the original selection model. In spite of this new formula including the (undesirable) English SATAP test, its power to predict the 2009 performance was tested; it was found to have limited value in predicting the 2009 overall final mark ($r = 0.23$, $p < 0.05$) and the proceed decision ($r = 0.22$, $p < 0.05$). Although this does highlight the underlying influence of English language proficiency, it also reiterates the changing nature of influential variables; moreover including a language proficiency test is an obviously undesirable solution given the preceding discussion.

With the significant influence of accommodation and the maths selection test on student performance in 2009, and the diminished explanatory and predictive value of the "M score", it was not possible to improve the discriminatory value of the selection model score for the 2009 cohort. To devise an improved selection model score formula therefore, the 2008 and 2009 cohort data were combined and rationalised (such as the removal of the transport arrangements data since this was not available for the 2009 students). The influences of the selection model score and accommodation arrangements on the overall average for the combined two cohorts are summarised in Figure 49.

Stepwise linear regression analysis (using only the "M score" and the maths selection test results) on this combined cohort data suggested that the following formula for the selection model score would be valuable in predicting the overall average mark for the foundation modules: 29.94 + (0.234 "M score" + 0.234 Maths selection score). This formula obviously is succinct, and does not necessitate the use of the science selection test nor the English SATAP test. The improved value of this new selection test over the existing formula was tested in further regression tree analysis that included all variables previously used in the generation of the 2008 and 2009 trees with overall average as the outcome variable (Tables 22 and 23).

The new selection formula reduced the heterogeneity of the root node better than the existing selection formula (Figure 50) (for the latter: improvement in purity = 12.85, λ coefficient for contingency tables = 0.86 by comparison). Accommodation remains influential for those students who are academically weaker as suggested by the selection model score (node 1), with females managing to perform better than their male counterparts if given secure accommodation. The influence of the English SATAP test scores continues to make an appearance, but the inverse relationship alluded to fairly often already is evident with some weaker students having higher levels of English language proficiency. This further reinforces the dangers of implementing English language proficiency tests for the purposes of selection.

A similar improvement in the explanatory value of the new selection model score over the existing one is seen in 2009 (Figure 51) with this score splitting the root node rather than the maths selection test as previously seen (Figure 45). This selection model score has a high cut-off value of 58, but is unlikely to be viable since it discriminates relatively few well performing students (node 2) from the bulk of others. Significantly the impact of accommodation is greatly reduced if students were to be selected if they achieved above this score, this variable not appearing as a primary splitter or surrogate anywhere in the tree, nor ranked highly in importance in terms of overall tree construction. Alternatively financial support is found to be important in those academically weaker students.

However, the role of secure accommodation remains paramount in determining whether students go on to proceed from the programme or not in 2008 and 2009 (Figures 52 and 53 respectively). In 2008 for those students who had not been given places in university residence the new selection model score would have discriminated well, particularly for female students (node 6). Male students, particularly those with lower levels of School English language proficiency and poorer performance in school maths and science would have been found to be riskier candidates (nodes 7 and 9).

In 2009, no student provided with secure accommodation would have proceeded from the Programme had they not achieved more than 52 new selection model score points (Figure 53). This new model score was found to be a good deal better than the existing selection model score in reducing the heterogeneity of node 2 (students given places in residence) (for the latter: improvement in purity = 0.06, λ coefficient for contingency tables = 0.86 by comparison). The unreliability of the NSC matric score is reiterated (nodes 7 and 8).

Figure 54 provides a summary of the relationship between accommodation and the value of the new selection model score in providing insight into what may best improve proceed rates from the Foundation Programme. For those students in 2008 and 2009 who were given places in residence, the new selection model score cut-off to ensure better proceed rates would have been 52, the score currently used (albeit with the existing selection model formula which includes the science selection test). For those students not in University residence, the cut-off score would need to have been higher (54) although this would still not have guaranteed that students would proceed (node 6) since clearly these students are at risk without places in university residence.

Further detailed examination of this tree, un-pruned, reveals a number of lower level splits made by the English SATAP test results. These splits are contradictory however, with some splits showing higher test scores predicting better Foundation proceed-rates and others suggesting that lower English SATAP test scores lead to a better proceed-rate. This final iteration of the diverse influence of the English SATAP test results on overall student performance and proceed rates reinforces the theory that the influence of English language proficiency is most profoundly experienced in the Foundation Biology module alone and remediation thereof needs to be specific to this module.

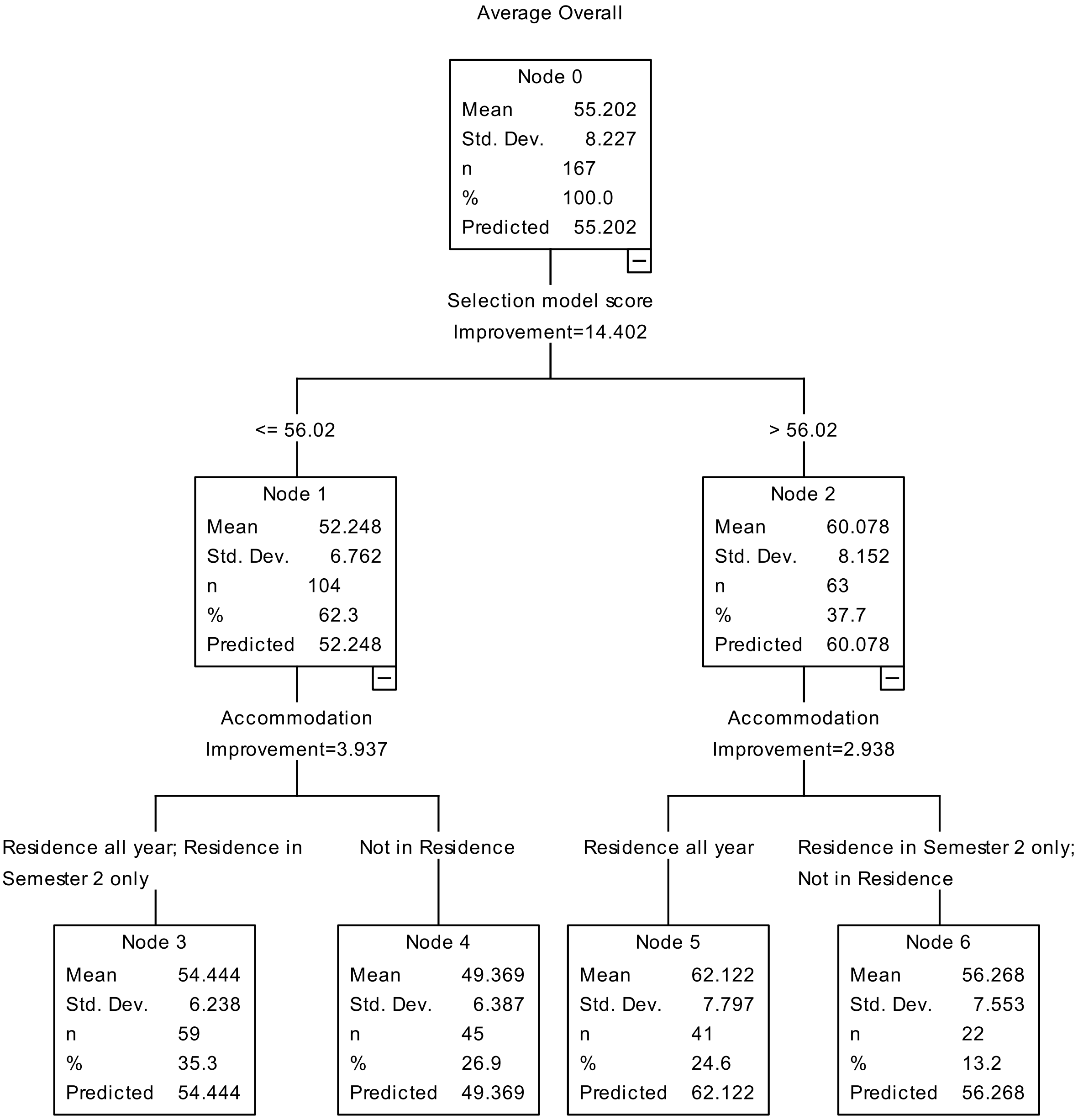

Figure 49. Regression tree for 2008 and 2009 overall final marks average (*N* = 167).

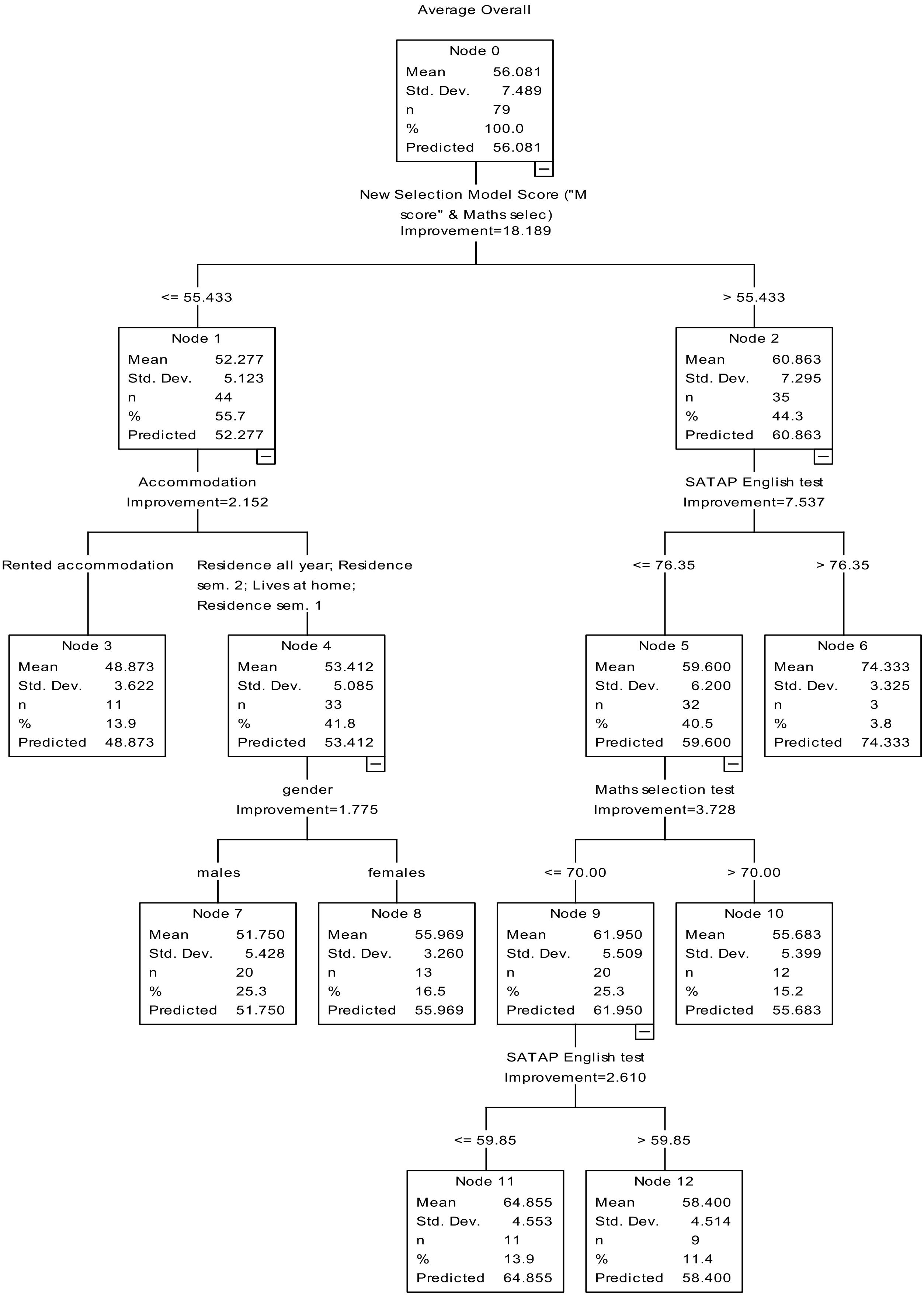

Figure 50. Regression tree for 2008 overall final mark average (*N* = 79) showing improved explanatory value of the new selection model score over the existing one.

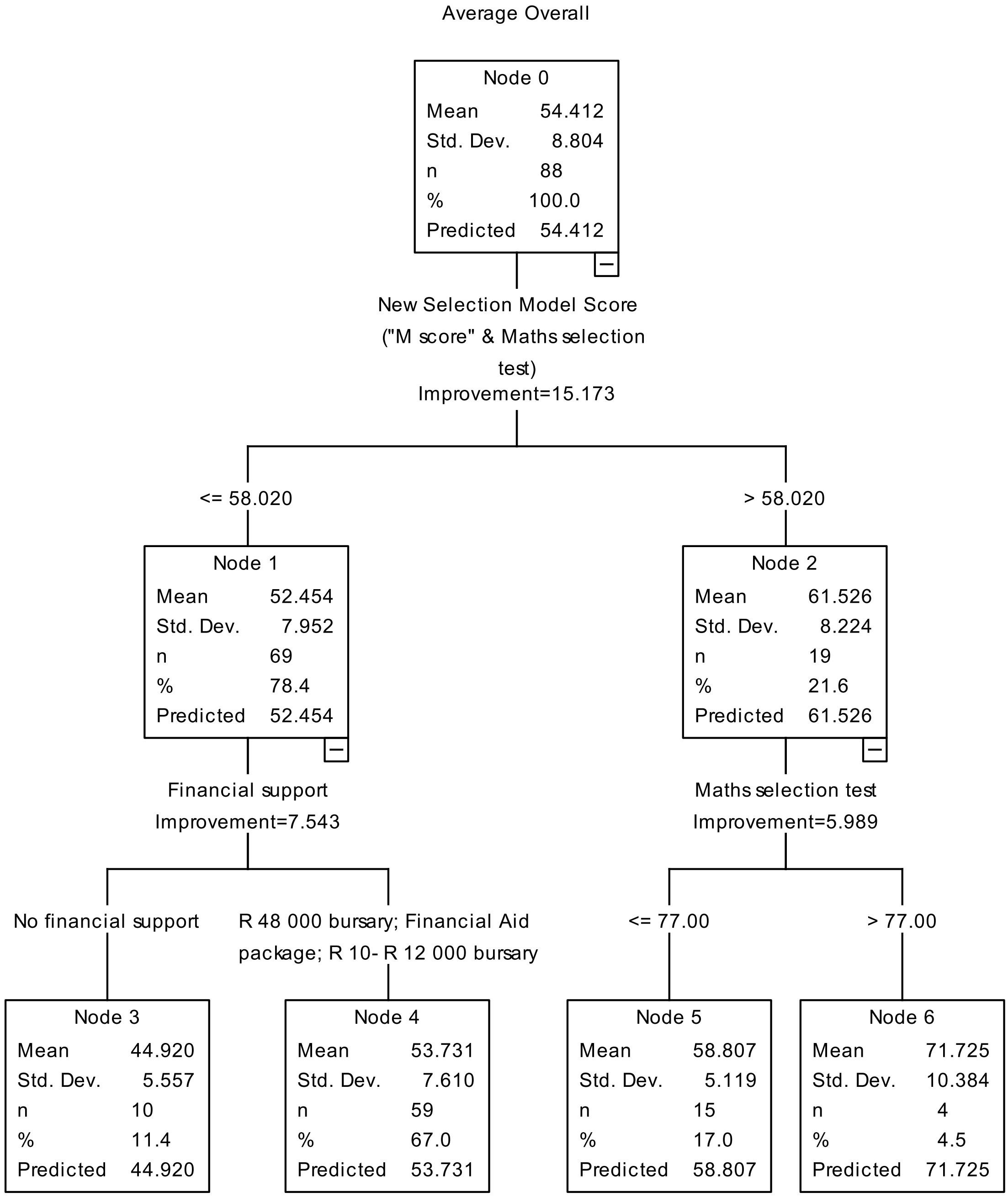

Figure 51. Regression tree for 2009 overall final mark average (*N* = 88) showing improved explanatory value of the new selection model score over the existing one.

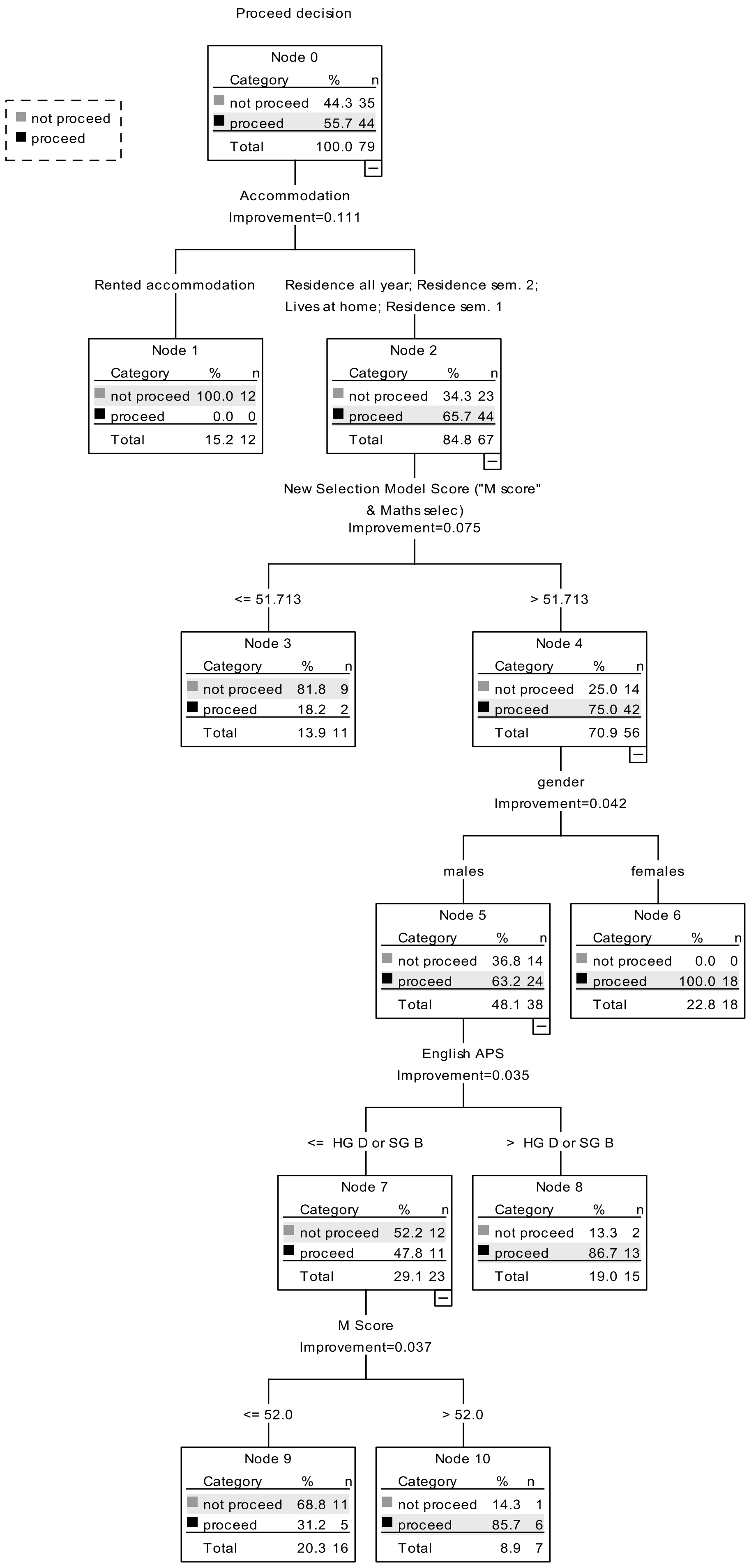

Figure 52. Classification tree for 2008 proceed decision (*N* = 79) showing improved explanatory value of the new selection model score over the existing one.

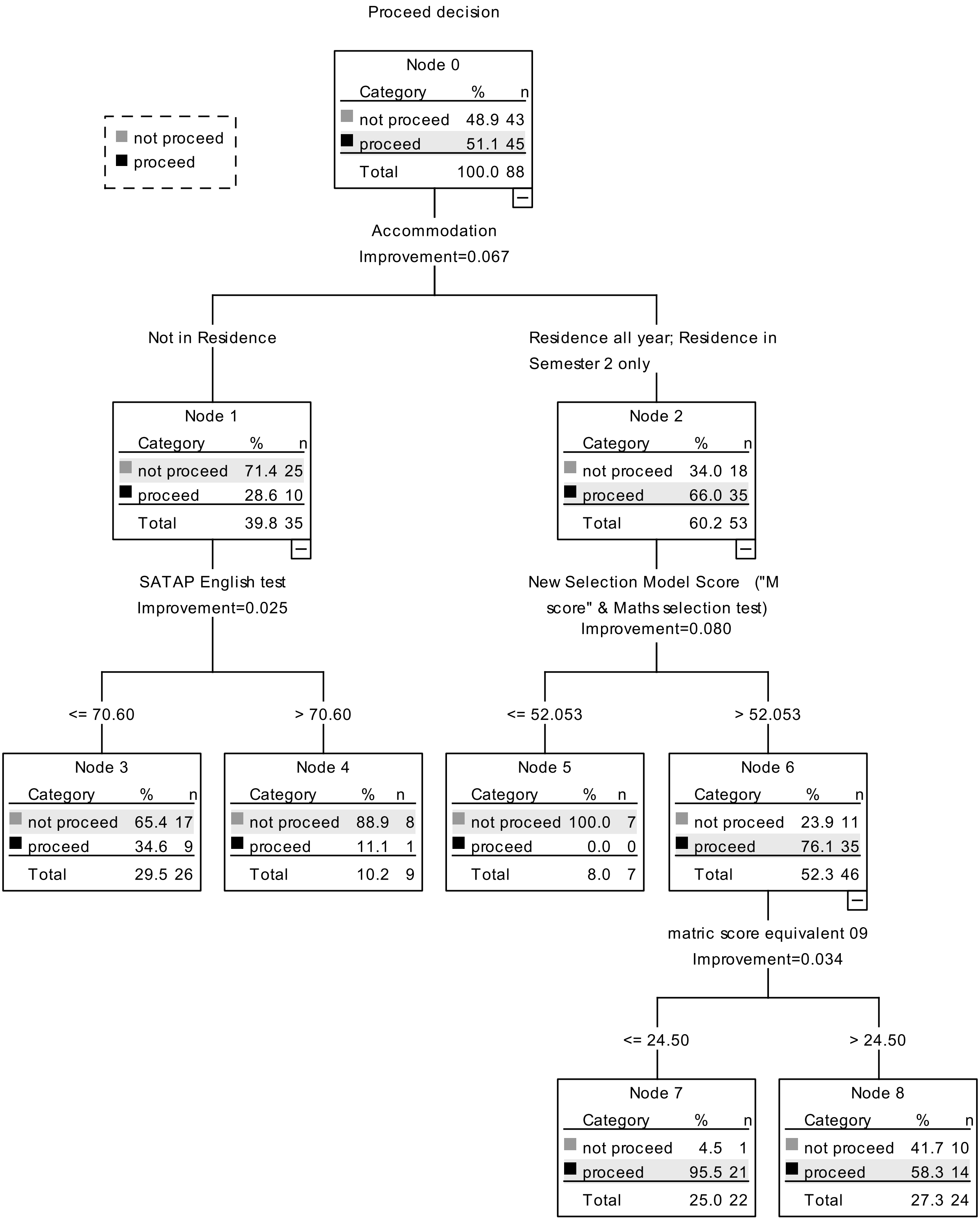

Figure 53. Classification tree for 2009 proceed decision (*N* = 88) showing improved explanatory value of the new selection model score over the existing one.

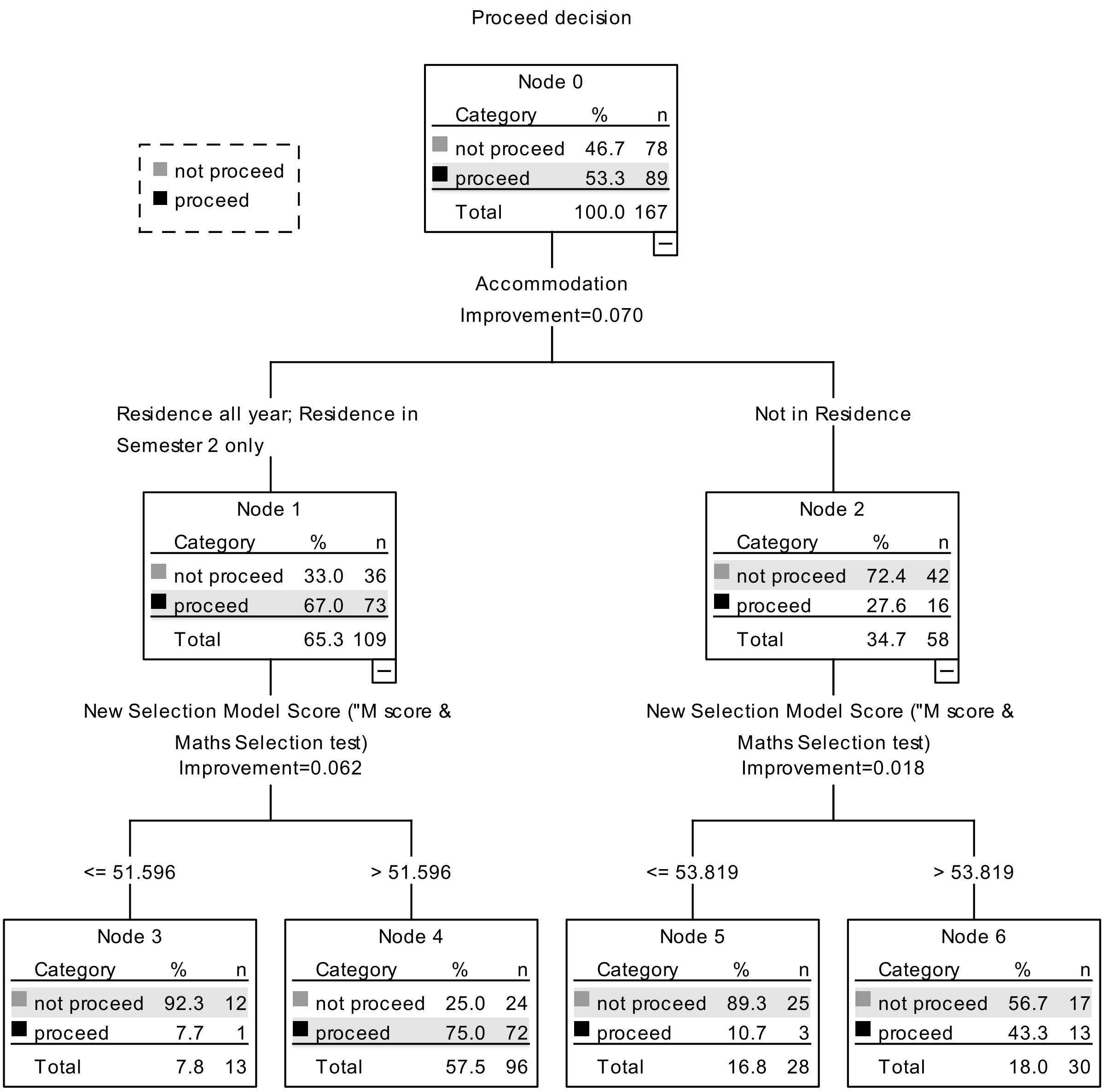

Figure 54. Classification tree for 2008 and 2009 proceed decision (*N* = 167).

Scaffolding Literacy in Biology

Given that student performance in the Foundation Biology module is influenced by factors other than those determining success in the other science modules, and in the Programme as a whole, a tension between access to, and success in, the Biology module, came to the fore. As such, the CSA selection mechanism has placed greater pressure on the Foundation Biology module than on the other modules in terms of ensuring student success after granting them access to the Programme; students selected on the basis of their potential as indicated by the selection mechanism may not necessarily excel in Foundation Biology where performance is largely determined by English language proficiency. Not surprisingly, English language proficiency has been shown to be most influential in the Communication in Science module too. Also not surprising is that performance in the Science Communication module is strongly related to performance in the Foundation Biology module (Figure 55). However, clearly the students' language development that takes place as a consequence of teaching and learning in the Science Communication module is not sufficient for weaker students (node 1), particularly those who come in with lower school English APS scores (node 3). In addition, it is clear that even if students do well in Science Communication, they do not excel in Foundation Biology (see node 5 where students have achieved between 56 and 66% for Science Communication, they have still only achieved 52% on average for Biology; this may be a consequence of the nature of assessment in the former, there being no examination component to this module).

In addition, the new selection model score is no improvement over the existing one in terms of selecting students for better performance in the Foundation Biology module (Figure 55).

It should also be remembered from previous chapters, that the Foundation students continued to be hampered by their English language proficiency in mainstream, and that their performance in the theory component was particularly weak. In addition to this large body of evidence, was the daily personal experience of teaching students whose standards of written work continued to drop with every passing year, and whose reluctance to read and prepare for class increased over time. The latter is borne out in the responses to an item included in the student evaluation already described in Chapter 8 (Appendix N; this question was included with the items pertaining to the general module evaluation which have been removed). The item in question made the statement, "To be honest, I did not read all the notes in my file". In 2008, 41% of the Foundation students gave "Strongly agree" and "Agree" responses (19% giving a neutral response and 40% saying they disagreed with this statement to a greater or lesser degree). In 2009, the number giving affirmative responses rose to 45%, and by the end of the first semester of 2010, the percentage had increased to 53%.

That South African English Second Language learners, particularly those from disadvantaged economic and educational backgrounds need academic language and cognitive skills to be explicitly mediated has become clear, and the argument for English language literacy learning to be integrated across the curriculum has also been made in Chapter 7. Whilst the Science Communication module has clearly been described as **not** being a "stand-alone course", the simple reality is that it IS a different module from Biology.

Parkinson et al. (2007) have said "… if content specialists valued academic literacy as much as content, the need for an academic literacy specialist would disappear" (p. 447). Despite this however, the current research is suggesting that remediation in English language proficiency in the Foundation Biology module curriculum must take place in addition to the language proficiency development that occurs in the Science Communication module. In the context of the foregoing discussions around language proficiency as a basic component of academic literacy, this calls for an even greater degree of integration of the former into the Biology module in line with the approach those working in the area of academic literacy in South Africa have been advocating for some time (for example, Jacobs (2005; 2010)).

Indeed, as Zaaiman et al. (2000) point out, selection of a student must be seen as an "implicit contract to teach at that student's level" (p.5), and if entrance requirements cannot be adjusted to ensure that every student selected has the best possible chance at succeeding, the teaching programme has to be adapted to match the level and requirements of the selected student body. To supply such support corresponds with the DOE's (1997a) principle of equity in that a student granted access, also has a fair opportunity to succeed, and of course speaks to the notion of epistemic access already explored.

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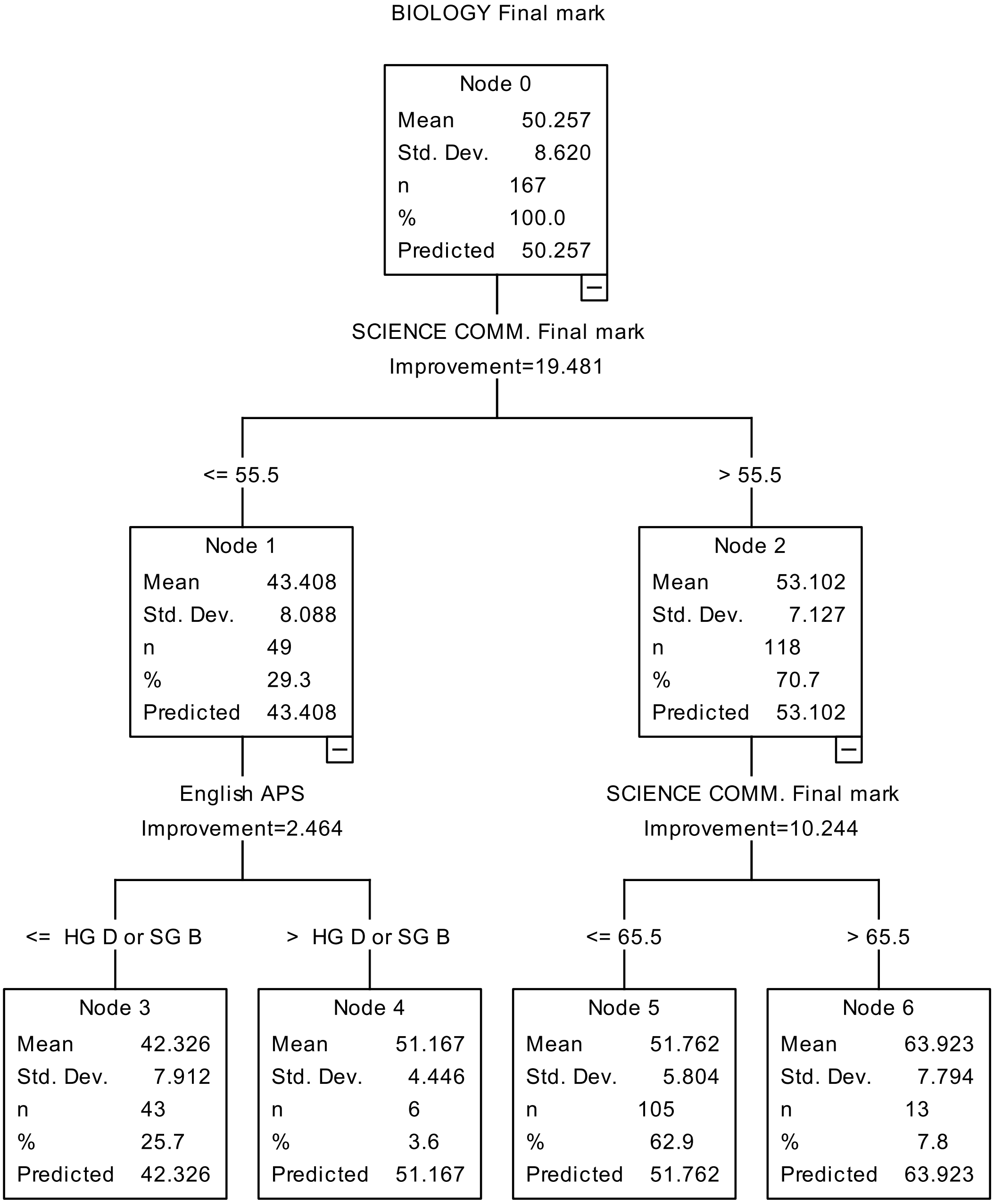

Figure 55. Regression tree for 2008 and 2009 Foundation Biology module (*N* = 167). All rationalised biographic, school history, socio-economic and selection test variables (including both existing and new selection model scores) included in construction of the tree. Performance in Science Communication module added.

Here the discussion around the relationship between language literacy and epistemic access to science in Chapter 7 is resumed. Many authors (Halliday, 1993; Halliday & Martin, 1993; Martin & Miller, 1999, Chapter 1) have long argued that language is central to learning; that it is the main tool for teaching and learning, and therefore should be integral to other learning. The importance of language to learning and concept development in science has also long been recognised (Vygotksy, 1962, explicitly outlined how, through the use of words, conceptual development in children occurs), but as Rollnick (2000) points out, recent theoretical work on learning in science has prioritised language even more than has been done so to date.

Yore and Treagust (2006) explore this fundamental role of language in the discourses of science, and science teaching and learning in some detail. Citing Duschl (2005) they describe the relationship between language and discourse along a continuum. At one end, that of the individual, “language and discourse (may be) perceived as a window into the mind” (p. 292). At the other end, considering the individual in society, language and discourse may be perceived as tools for achieving “cultural capital, and the construction, representation and dissemination of knowledge claims” (ibid).

As Wellington and Osborne (2001) relate: “Paying more attention to language is one of the most important acts that can be done to improve the quality of science education” (p.1). These authors describe a science lesson as a language lesson and refer to Postman and Weingartner (1971) to illustrate this view: “… a discipline is a way of knowing, and whatever is known is inseparable from the symbols (mostly words) in which the knowing is codified. What is biology (for example) other than words?” (p. 3). Moreover, these authors acknowledge that they view language as a major barrier to most students’ learning science, quoting Byrne et al. (1994) as saying “… thought requires language, language requires thought. Viewed from a negative angle, difficulty with language causes difficulty in reasoning” (p.6).

From this perspective (that language development and conceptual development are inextricably linked), given that Foundation Programme students have not had the opportunity to develop their cognitive academic proficiency (CALP) in their home languages before their schooling switched to the medium of English as the language of instruction (Chapter 7), it stands to reason that their conceptual development in science will be hampered without the concurrent development of their proficiency in the language of instruction (at UKZN, English).

As has already been outlined, Parkinson and colleagues (2007; 2008), in the development of the Communication in Science modules, have recognised that reading is essential to writing, and only in the presence of good reading and comprehension skills, can a student be expected to write effectively. However, it is well recognised that South African English Second Language learners are disadvantaged with respect to this, given that their school experiences have left them decoding text at the expense of comprehension (Chapter 7). Moore and Hart (2007) report that the READ Annual Report of (1999) indicated that Grade 8 ESL learners in rural areas with an average age of 14.4 were reading at age level 7.6! Hart, at the “Learning to read: Reading to learn” workshop on scaffolding academic literacy held at UKZN in September, 2006 also spoke of comprehension levels of 30% in ESL grade 6 learners which, he explained amounts to “frustration levels” of up to 70%. When learners experience such high levels of frustration with reading, they give up, and resort to listening rather than reading to learn, an approach to learning that they carry through to the completion of their schooling. It is these students, many of them operating at unacceptable frustration levels, who are given formal access to the Foundation Programme.

Reading science in a second language. Reading is an activity that practising scientists spend a lot of time engaged in. This is important to acknowledge when considering the social constructivist orientation of the Foundation Programme. However, as already pointed out, this important activity is generally uncommonly practised at school in South Africa, and reading in science unpractised all over the world (in particular reading that is deliberately planned) (Wellington & Osborne, 2001). Rose (2007) notes that, conversely the language teaching of written texts (and of spoken language) has received much attention.

In addition, reading science is difficult. Not only is the discourse of science unique, but it is full of discipline-specific words that are unfamiliar to everyday contexts. Cleghorn and Rollnick (2002) cite Lemke (1990) when pointing out that even for English First Language learners, “reading, writing and talking about science” are often difficult because the discourse and practices of science are new and unfamiliar.

However, English First and Second Language learners will undoubtedly experience science text differently. The extract below from Lewis Carroll's "Through the Looking Glass" (as quoted by Wellington and Osborne, 2001, p. 9) provides an illustratration of this:

> "Twas brillig and the slithy toves,
> Did gyre and gimble in the wabe,
> All mimsy were the borogoves,
> And the mome raths outgrabe".

Although the words may be unfamiliar to an English First Language learner (just as the technical words of science may be), such a student is most likely able to (correctly) answer questions on the text, using their knowledge of the way the English language works. Although the answers lack comprehension and meaning ("What activity did the slithy toves get up to? Where did they do this and when?

a. gyring and gambling

b. in the wabe, at brillig"), such superficial responses are more than likely sufficient for getting by. Lacking this understanding of the structure of, and rules for English, an ESL student is much more unlikely to cope. Conversely, a better understanding of how English works is likely to help an ESL learner immensely with their academic studies. Better still, if they are explicitly taught it in context of their science studies.

Indeed, many authors (e.g. those cited by Rollnick, 2000; Wellington and Osborne, 2001, and also recognised by Parkinson, 2007; 2008, in the design of the Communication in Science modules) have found that not only does the technical language of science pose problems for students, but perhaps even more problematic are the semantics of non-technical everyday language and vocabulary in a science context. Others (e.g. Marshall, Gilmour and Lewis, 1991) have shown that many English First and Second Language learners' understanding of non-technical words is actually opposite of the true meaning; this is compounded where words have multiple meanings. Moreover, many technical words have other everyday meanings (or vice versa). In addition, are the syntactical problems associated with the use of logical connectives, in particular those that require inferences to be made, those that involve comparisons or causality, and those used in stating hypotheses (Wellington & Osborne, 2001). Thus, these authors and others have recommended that teachers should devote time within science lessons to the overt teaching of the semantics of non-technical vocabulary in the context of science, as well as scaffolding the understanding of technical, scientific words. This is reinforced by Clarence-Fincham, Hart, Inglis and Jackson (2002) and Downs et al. (2001).

Yore and Treagust (2006) reflect these views when considering what is necessary in the achievement of science literacy (and science citizenship). These authors describe science literacy as requiring, in a fundamental sense, proficiency in science language and thinking, which in turn influences the second component of science literacy, the derived sense which refers to the issues such as “understanding the nature of science, the big ideas of science, and the relevance of the interactions among science, technology, society and environment” (p. 295). These authors refer to Yore (2000) when explaining that learning how to talk, write and read science requires the explicit inclusion of language tasks and language instruction into pedagogy. This in turn will enhance the “derived sense of science literacy – talking, writing and reading to learn science” (p. 296). These authors cite Gee (2005) when suggesting that the acquisition of the language of science will involve some loss in home language as enculturation into a science discourse community is facilitated. Yore and Treagust (2006) are also very clear that, in future teacher education and professional development, a far more important role will need to be assigned to language in teaching, learning, and doing science.

This resonates with findings of Bohlmann and Pretorius (2002) who call for a focus on reading as a fundamental skill underlying academic performance, saying “if students can be given opportunities to improve their reading in the context of mathematics, they should have a better chance of success” (p. 205). As these authors point out, not only does reading allow learners to independently access information, it is an important learning tool as it offers opportunities for constructing meaning and consolidation of this into new knowledge (this certainly rings true within the context of the constructivist pedagogy of the Foundation Programmes of the CSA). Pretorius (2002) points out that language proficiency and reading ability are not the same thing. Giving attention to reading will improve reading skill and in the process language proficiency will also improve.

Clearly, any student endeavouring to successfully become a scientist needs to be capable of reading carefully, critically, with comprehension, reflection, and appropriate scientific scepticism (Wellington & Osborne, 2001). These skills will enable them to present coherent analysis, argument or discussion in their own written work, and facilitate independent study (Rose et al., 2003).

"Learning to read; Reading to learn". Rose (2007; 2011) argues strongly that reading is at the core of teaching and learning, and systematic approaches to teaching reading should be at the heart of any pedagogy. This conviction had led Rose and colleagues to propose a modified version of Bernstein's distributive rules of the "pedagogic device" (Bernstein, 1996 cited by Rose, 2007). Substituted in place of Bernstein's restricted and elaborated categories of consciousness are an "orientation to interacting with books" and an "orientation to interacting with people" (Rose, 2007). Given the problems around language literacy in South Africa that have been described, this has obvious implications for inequality within the pedagogic discourse, classrooms and communities as the order and relations of economy and society are recontextualised in education. This author goes as far as to propose that the omission of explicit teaching of reading in schools is a hidden curriculum aimed at ensuring that the majority of learners proceed to vocational or manual occupations (p.44).

Rose (2007) describes this hidden curriculum that culminates in the success of only those learners who tacitly and independently learn to process text, and reproduce language patterns by the end of their term of formal schooling. Learners follow a sequence of reading development that begins before formal schooling with parent-child interactions. It is here, in typically middle class literate communities that children learn to conceptualise books as partners in exchange of meaning. Indeed, this is essential for the next phase in the sequence to be achieved, that is independent reading (with engagement and understanding), which normally takes place in the junior primary levels of schooling. This progression is far more challenging for learners from oral societies who missed out on the parental induction into meaningful engagement with text, and for whom such an interaction is a "strange form of consciousness" (p. 40). The third stage in the reading development sequence (learning to learn from reading which typically takes place in the later years of primary schooling) is subsequently negatively impacted upon if independent reading is not sufficiently well achieved in the junior primary years of school. Similarly the fourth and fifth levels (independent learning of academic genres during secondary school and independent academic study at tertiary level respectively) are never adequately achieved if grounding in the preceding levels is insufficient. Each of the stages prepares successful students by equipping them with skills necessary for the following stage. However, students are evaluated at each stage on their achievement of the necessary conditions preceding each stage (by which time those who were unprepared for the next step are obviously already failing to achieve, setting in motion the delineation of students as successes or failures right from the start; this has particular consequences for those who never received the initial grounding in the home). Furthermore, as Rose points out, the age-based nature of the sequence (related to levels of schooling) is actually arbitrary (p.64) (see also Bloch's work on emergent literacy, e.g., 2006). Moreover, beyond the first few years of formal schooling, explicit reading instruction ceases (see also Chapter 7). The non-progression through this school-based sequence of development has resulted in the high frustration levels of many tertiary learners in South Africa, most particularly those for whom English is a second language (De Witt, Lessing & Dicker, 1998; Moore & Hart, 2007; M. Hart, personal communication, September 13, 2006).

Given their standpoint, Rose and colleagues (2003; 2006; 2007; 2011) have devised a "scaffolding" methodology that they believe is an effective way for teachers to support students to read authentic texts required of university study, but which are beyond their independent reading abilities. As such, their scaffolding model extends from the work of Vygotsky and others on the social scaffolding of learning in the "zone of proximal development" (Rose, 2006). In the process, teachers first model successful practice. As learners successfully practise complex skills with guidance and elaboration from a teacher, they gradually develop reading independence and competence, and the scaffolding is then slowly withdrawn. Their approach thus explicitly takes cognisance of the influence of scaffolded learning cycles on ontogenesis which assumes that for a learning task to be successfully carried out, some preparation must have occurred before, followed by elaboration afterwards. This three-part cycle of prepare-task-elaborate is applied at all levels of Rose's programme, from curriculum planning to micro-interactions in the classroom (see Rose, 2006; 2011). In the classroom, all three steps involve guidance from someone more experienced, thus making explicit the processes of social learning. Rose (2007) describes this as "temporalising" the learning process, and compares such an empirical step-by-step approach with the more dualistic stances (such as learner-centred versus teacher-centred learning). This resonates with the approach of Wellington and Osborne (2001) who describe "active reading" as requiring three elements namely, a purpose, a coach and collaboration (p. 44). Readers need to be given specific targets and instructions, a coach who scaffolds and guides the process, and an opportunity to receive feedback from other readers as well as the text itself.

Rose's scaffolding strategies for reading and writing are designed to focus learners' attention on patterns of language and to recognise the meanings they express. Indeed; the strategy has developed out of the Genre Approach to teaching literacy (Rose, 2007; 2011), which itself has arisen from theories of "language in use" and Systemic Functional Linguistics (Moore & Hart, 2007). The approach has achieved much success with indigenous adults returning to study at the University of Sydney, Australia, and also in Latin America and South Africa (Rose et al., 2003). Other independent evaluations have found it to be up to four times as effective as other literacy approaches (McRae et al., 2000). It has been found to reduce the gap between the highest and lowest performing students, and students who have been through the process have demonstrated an overall improvement in confidence and engagement in their tertiary study (across the curriculum).

Rose (2007; p. 51) describes his scaffolding pedagogy as underpinned by a stratified model of "language as text in a social context". It is the patterns of discourse at each level of language that are primarily emphasised, but importantly it is also recognised that meaning in discourse systems is realised in the grammatical systems. Thus attention is given at the global level of text as well as to the grammatical structures. Indeed, the framework of Systemic Functional Linguistics/ Grammar sees language as a resource for making meaning effectively in different contexts to achieve particular communicative purposes (Halliday, 1993; 1994; Halliday & Martin, 1993; Moore & Hart, 2007). Boughey (2005) describes it as the context-dependent choices about language use; how appropriate the choice is depends on the situational and cultural backgrounds (in a university, the latter refers to the institutional culture).

Rose (2007) describes this hierarchical model of language referred to above, the basis of which is the letter patterns (spelling) in words. These are subsumed by patterns in the sentence and text (grammar and discourse respectively), which are in turn included in patterns in the context (register and genre) at successively higher levels. The context brings meaning to the text; the register includes the field (subject matter and the degree to which the situation is commonsense or specialised), tenor (the relationship between writer and reader), and mode (the degree to which the language is written or spoken) (Droga & Humphrey, 2003). The genre specifies the particular social purpose of the text in context of other genres in a culture (Droga & Humphrey, 2003; Halliday, 1994; Rose, 2007). Subsuming all these layers are the ideological messages that the text encodes. Rose (2007) explains that reading and writing (like speaking and listening) require the simultaneous and automatic processing of all of these layers, and substructures (such as syllables, phrases and paragraphs within the text).

In recognising that students from oral cultural backgrounds in particular, and those who have not successfully moved through the reading development sequence described earlier, may not successfully transfer learnt patterns of language from one context to another, the Rose scaffolding strategy works systematically through the levels of language patterning from the highest (context including genre and field) to the lowest (at the lexical level). At first a global framework is orally provided to allow students a general understanding of the genre and field to prepare them for reading the text. Preparation may include directed discussion; the text is then read aloud with students following. This allows students to attend to the sequence of meanings rather than to the decoding of the text. “Detailed Reading” follows where the text is read aloud with attention being paid to the meaning of groups of words in sentences, and their role in the sentence and the text (Rose, 2006; 2007; Rose et al., 2003) (obviously this would include a presentation and explanation of the specialist words and forms of language that are unique to the field of science as advocated by Wellington & Osborne, 2001 and Inglis et al., 2007). Writing activities (beginning with note taking) follow using the language patterns of the discourse, and to a lesser extent, the grammatical structure of the read text.

Learning through such a scaffolding strategy relies on the success of dynamic interactions between learners and teachers, in particular negotiation (Rose, 2007). Rose describes seven types of exchange moves in a learning interaction, namely “query”, “prepare”, “identify”, “select”, “affirm”, “reject’ and “elaborate”. Affirmation opens up the potential for learning; rejection closes it down (Rose, 2007, p.58). Scaffolded interactions that promote learning will be initiated by a “prepare” exchange move. Often in a classroom interaction there is a difference in the query or preparation and the expected, desired response from learners leading to negative learning experiences which are often regulative and reinforce inequality in the learners. Rose (2007) points out such interactions often privilege only those students who have the most experience in negotiating the semantic relationship between oral and written discourses; conversely they serve a regulative function for those who don't. By heavily scaffolding the learning cycle through carefully planned classroom interaction during "Detailed Reading", students are able to read text that would otherwise have been completely inaccessible to them. On a larger scale, the planning of curriculum and instructional sequences take place around rigorously selected texts for progression within a programme (Rose et al., 2003).

Towards a conclusion… Thus, by diverting pedagogic practice towards teaching to learn from reading, by making changes in curriculum sequencing to ensure that all students have equal access to the written discourses that realise, and give meaning to the content of their curricula, and by taking care with the design of teaching interactions, Rose and colleagues propose that the inequalities brought about by what they, and Bernstein (1996/2000) refer to as the "distributive" and associated "evaluative rules" of the "pedagogic device", may be reversed (Rose 2007, p.64).

Boughey (2005, 2008) has a similar view. As this author points out, central to the framework of Systemic Functional Linguistics is that language use is about choice-making. These choices are made against contexts of culture and situation. A mismatch between the dominant context of culture and situation of the university (where students are situated) and the contexts of culture and situation to which students refer when making choices in language use presents a challenge to epistemic access. This author provides examples of such mismatches: an educationally disadvantaged student may well regard the authorial position of text as being didactic because of the influence of religious preachers in their communities. To facilitate epistemic access to such a student, and enable them to "develop their own voices" (Boughey, 2005, p. 237), issues of tenor (see above in this text, p. 273) will need to be explored. Similarly, a disadvantaged student, who has applied a primary discourse to a formal essay writing task, will require support to identify the mode appropriate for this academic task.

Similarly, Rollnick (2000) advocates a "writing to learn" approach when considering responses to the challenges students face when learning science through a second language. Rollnick (2000), citing Swales (1990), explicitly identifies with the English for Specific Purposes movement (ESP). In applied linguistics ESP subsumes the English for Science and Technology movement (EST). EST is concerned with helping learners to become sufficiently proficient in English to be able to work with Science and Technology (Rollnick, 2000). This approach draws from the work of the systemic functional linguists with whom the research presented here has already been aligned, in particular the work of Halliday (1993, 1994) and Halliday and Martin (1993). The term “communicative competence”is significant within the ESP movement; “competence” refers to the mastery of the genres of scientific discourse, language being recognised as a communication system where the meaning and function of language is context- and culture dependent.

This notion of “communicative competence” is most useful in refining substantive theory within the context of the Foundation Programme at UKZN. In achieving proficiency in the genres relevant to studying science at tertiary level, fundamental to which is gaining a functional level of efficiency in reading and writing in the medium of English, Foundation Programme students may join that distinct discourse community, and share in its community of practice. As such, students need to achieve *functional communicative access in the first instance before epistemic access may be realised.*

Rose’s “scaffolding” literacy project arose in a context where academic literacy was traditionally taught in a fashion similar to most other tertiary institutions, including UKZN: i.e. presentation and discussion in lectures and tutorials, the provision of articles to read (with no explicit teaching of how to access the text), followed by written assignments. Similarly, as has been experienced in the Foundation Biology module, students “rarely did the reading” required of them, (or indeed, *could* not), so that in-class discussion from the students’ perspective amounted to their personal experience (Rose et al., 2003, p. 42) (and because students’ academic reading was so limited, their written work also developed very slowly). In Bernstein’s terms, the distributive rules of such a horizontal discourse acts to ensure that these students never gain epistemic access to the vertical discourse of the academic field.

Thus, what is being proposed here is that for students to be afforded epistemic access to mainstream life science studies by successfully completing the Foundation Biology module, they first need to be *explicitly supported to achieve functional communicative access after formal access* to the Programme. The implementation of such a literacy strategy as that described above into the Foundation Biology module might well afford this access; it is indeed consistent with the national language policy for higher education which seeks to “ensure that the existing languages of instruction do not serve as a barrier to access and success (DOE, 2002a, p. 5), and the current language policy of UKZN (2006c).

Paradoxically, this approach, that is to explicitly include the teaching of reading and writing in English in a science curriculum, is seen by this researcher as being at least one step closer to being consistent with the enviable movement of the multilingualists in South Africa (briefly alluded to in Chapter 7). In their bold attempts to address the fundamental problems that hegemony of the English language poses to democracy and equality (given the issues surrounding the relationship between power and language) in South Africa, they also acknowledge the reality of the dominance of the English language in the context of globalization and modernization, and the implications this has for the economic and technological future of South Africa. The proponents of multilingualism recognize that "immediate empowerment" comes by way of the foreign language (Alexander, 2000, p. 15) (which in the context of UKZN, and arguably much of South Africa, is undoutedy English), and this will be the way for the foreseeable future ("certainly for the next two or three generations") until such time as the African languages can "hold their own with English (and Afrikaans) in high-status functions throughout the economy and society" (ibid, p. 17). In a similar vein, Cele (2004) calls for the Africanisation of English, alongside the development of indigenous languages in pursuit of a balance between economic emancipation and education, and training for public good, and social justice.

At this point it is relevant to quote from the work of arguably one of the most influential voices researching language in education in South Africa, Neville Alexander "….we are in the vanguard of those in South Africa who demand that access to English become the right of all those who want it, precisely because such access is the key to power at certain levels of South African society as it is structured at present" (Alexander, p. 2000, p. 15). No doubt, epistemic access to tertiary science study, at least at this time in South Africa's history, requires learners to have acquired functional proficiency in the lingua franca.

A final note. The pedagogical perspectives offered above have resonance in the postpositivist approach this study has taken, and with the reconstruction of the philosophical basis of the Foundation Programme that has been proposed, namely the form of constructivism described in Chapter 4. It is fitting and indeed consilient that Rose himself should identify his pedagogy as being anti-dualistic (2007, p. 70-72), a position identified for post-positivism (Chapter 2), and in the employment of classification and regression tree analysis for the abstraction of substantive theory (Chapter 3). After all, what truly counts is not that energy be expended on defending polarised positions of one form or another, but that students are genuinely provided with opportunities that allow authentic access to successful completion of their studies. Such a discourse speaks to achieving equality in our classrooms and in society.

AFTERWORD

This study has allowed an additional glimpse into the tumultuous world of South African Education. There are major concerns around education having lost value in our society, and in particular in rural communities. As Professor Jonathan Jansen, arguably one of the most rational voices speaking out amidst this turmoil laments, education in our country is no longer seen to be a "route out of poverty" (2012, p.7). Instead there exists a perception that material prosperity can be achieved without an education, an understanding achieved through, to a large extent, the manifestations of corruption.

Jansen (2012) calls for a change in South African societal culture, acknowledging that there are no "short cuts"; a society that places "education at the centre of the agenda for change", one where books no longer "take second place to rocks" (p.7). Wise words indeed, and especially significant when the message is conveyed in the popular media which is accessible to all of society...as long as that society can read.

Indeed, this study has reinforced my conviction that there is no greater, nor important, gift one can give than to inculcate a love of reading. Without any substantial foundation upon which to build, on being given formal access to an English medium University, heavily dependent on text for learning and assessment, the Foundation Programme students were severely disadvantaged by their English language literacy. And a life time of inadequate preparation cannot be made good in a short academic year of twenty six weeks, no matter how carefully designed, or well implemented, the curriculum of any alternative access programme.

Currently Government is acknowledging that the national preoccupation with the crisis in education that has focused on secondary schools to date, must make way for action at a much more fundamental level (Green, Parker, Deacon & Hall, 2011; Motshegka, 2011; see also The School of Education and Development, UKZN, 2010). Aside from initiatives allowing alternative access to tertiary education which have been the focus of this study, educational interventions in the past have mainly focused on school level Grades 10, 11 and 12 and usually only aimed at mathematics and science. However, "lurking behind the intractable problem of low pass rates, the dysfunctional schools and the small number of higher grade mathematics and science graduates is the calamity in primary education" (Fleisch, 2008, p. 164).

The 2011 Annual National Assessment (ANA) results that were released by the Basic Education Minister, Angie Motshegka, brought attention to the under-emphasis in education on basic literacy and numeracy which are recognized to be fundamental to further education and achievement in the worlds of both education and work (Motshegka, 2011). In her address to the nation in 2011, Minister Motshegka acknowledged an important fundamental issue: “every grade up requires support further down”. So if any meaningful learning is contingent on the preceding foundations laid, it stands to reason that early childhood literacy, and the sound development of the basic skills of reading and writing (and numeracy), at the Foundation phase level of schooling (and even before that) is paramount.

This is the view of Bloch (e.g. 2002; 2005; 2006) and Alexander and Bloch (2004) in particular, who have long recognized the deficiencies in pedagogical approach to early literacy teaching as being the basis for South Africa’s education woes during apartheid and in subsequent years (Bloch, 1994). As these authors explain, the paradigm of early literacy learning is however moving away from viewing literacy as being made up of sets of technical skills, separate from real context, towards one of understanding that literacy learning is socio-cultural in nature, and is part of everyday activity. What is done with reading, and in what particular context, is significant as it provides opportunities for making meaning. Moreover, and most importantly, the element of enjoyment, imagination and play is crucial to meaningful literacy learning, especially in a child’s early years (see Bloch, 1997). Approached like this, technical skills are learnt simultaneously, as learners “learn to read by reading” and “write by writing” (Bloch, 2005) – and a positive relationship is established with text, and text-based learning. This is in contrast to the technical approach where skills are taught, from simple to complex, from part to whole with an emphasis on phonics and letter formation, and assumes that only when these technical skills have been mastered, can children use reading and writing for useful, meaningful reasons. As Bloch (2005) asserts most South African children, even those growing up in more affluent, resourced homes where text may feature regularly in everyday life are not given much incentive to read or write for real reasons at school. Making the shift requires teachers to examine their own beliefs about learning, and to experience good practice that allows them to realise that the skills required to learn to read and write can be taught in meaningful contexts in a holistic way.

This whole language, or emergent reading and writing view of early literacy holds that young children "construct their own literacy in personally useful and meaningful ways as part of their developmental and social learning processes" (Bloch, 2005). This approach does not require learners to be "reading ready" which holds that the development of certain skills (e.g. visual and auditory discrimination, fine and gross motor skills) are prerequisites for learning to read and write. This approach to early literacy learning has been promoted in government policy documents for some time (DOE, 2002b, p.9), but has not been translated into practice in most South African schools (Bloch, 2005, 2006).

Research into the nature of oral-language learning of babies and small children has impacted on emergent understandings of early literacy. Early learning of oral language happens when young children interact with, and are exposed to, people as they go about their daily activities. Such experiences are highly motivating for the young learners as they accomplish things in using (learning to use) the language; in addition there is an affective aspect to this learning as emotional satisfaction is integral to the experience of using the learned language (Bloch, 2006). Bloch (2005) reports research that suggests that learning written language can, if conditions are favourable, be very similar to learning oral language. Such conditions include an environment where they are motivated by those around them to engage with print in a positive, meaningful and enjoyable manner, be involved in rich and creative language play/ use such as listening to, and telling, stories, songs and rhymes, wordplay and conversations, be encouraged to behave like "readers and writers" and to understand the connections between oral and thought language, and the possibilities of these being written down and then read, be self-motivated and willing to make mistakes and take risks (p. 9).

If such conditions exist, a child can learn the different interrelated aspects of language (listening and talking, reading and writing, and translating and interpreting in the case of multilingual environments) all together. Bloch (2005) reports instances of children as young as four writing their own stories, willing to take risks and make mistakes (by applying their own phonic knowledge), which provided opportunities for learning. Simultaneously, fine muscle tone and small-motor co-ordination is developed through the direct activity of writing.

This approach recognizes the importance of young children's symbolic play and imagination to their early literacy learning. Playing with languages develops a child's phonological awareness (the sound structure of spoken words), an important literacy learning skill. In this context, listening to, and telling stories is a highly valuable activity as such activity exposes a child to a rich and complex form of language (Bloch, 2005). Alexander and Bloch (2004, p. 8) describe the advances of story telling by quoting Wells (1985, p. 253): “because stories are self-contextualizing, sustained symbolic representations of possible worlds, they provide the child with the opportunity to learn some of the essential characteristics of written language. Reading and discussing stories helps the child to cope with the more dis-embedded uses of spoken language that the school curriculum demands”.

Such a learning framework assumes that children have experienced the influence of people modelling reading and writing behaviour for them, have had plenty of opportunities to interact with people around print which has encouraged them to behave like “readers and writers”, and that these efforts have been recognised and valued. There is thus a strong affective aspect to this approach to learning. Meeting these requirements provides conditions that allow children to feel sufficiently equipped, motivated and secure to attempt to learn to read and write themselves.

In spite of a school language policy in South Africa that promotes additive bilingualism, it is well known that this is not a reality in the majority of classrooms, as outlined in Chapters 7 and 10 in particular. At no other stage is this more of an issue than in the first few years of schooling when learners’ literacy foundations are being laid. Constructivist theory (implicit in the Revised Curriculum Statement for Languages, English- Home Language) (DOE, 2002b, p. 9) requires that what learners know when beginning school is taken into account for any new learning experience. Given that what most young children will have learnt before starting school will have been learned in their mother tongue, (and that appropriate and effective teaching begins with and builds on what children already know and can do), it is obviously preferable that learning at school begins in the mother tongue (Alexander & Bloch, 2004).

In many multilingual classrooms this does not always happen (ibid). Further-more, if learning **does** occur in the mother tongue in these foundation years when children are learning to read and write, by the same argument this does not prepare them to learn in English when the abrupt switch in language medium is made after these initial years (also discussed in Chapter 7). Either way, even though in the multilingual classrooms of South

Africa, a choice has to be made with respect to the language of teaching, other ways can, and should, be found to support bilingual literacy teaching and learning in both mother tongue and English (Bloch, 1997; 2002; 2005).

However, the print-rich environments (and all the other concomitant conditions described above) that are required for children to be able to benefit from bilingual/ multilingual emergent literacy in practice do not exist in communities where African languages predominate (described at length in Chapter 7, but also see work of Bloch especially). Not only is there a need for a dramatic increase in the volume and availability of print material in African languages, but a change in the low status of these languages as print languages is crucial for a bilingual/ multilingual approach to literacy learning to be a possible solution to South Africa's literacy crisis. As Bloch (2005) says: "…we all need to think about the messages that are being given to people about the power, status and use value of their language/s as print language/s if they rarely or never see these used in writing" (p.14). In this vein, Alexander and Bloch (2004, p. 2) explain the importance of distinguishing between the hegemony and the dominance of the English language.

It is against this theoretical backdrop, and in context of their recognition for the need for deep-seated, fundamental and personal changes in views around language, literacy and pedagogy in all those who are engaged in education (Bloch, 2006), that Bloch and her colleagues have devised classroom strategies to help teachers develop early (bi)literacy in the manner described above (see for example Bloch, 2000, 2006).

Perhaps even more promising is their venture from conventional classrooms into homes and communities in their reading club initiative, Nal'ibali (see http://nalibali.org/). Indeed, the traditional, skills-based model of literacy learning that has largely assumed that learning can only happen in the classroom under the authority of a teacher and when certain preliminary ‚"school-readiness" skills have been mastered (and which has been hegemonic in South Africa) has neglected the inherent learning ability of the human mind; the parent, the youth leader, the volunteer, and the child. Rejecting this view opens up countless possibilities for meaningful literacy learning, and the Nal'ibali programme does just this.

The Nal'ibali initiative aims to promote the establishment of reading clubs (in any safe, informal and relaxed environment in a community) that can provide regular opportunities for children to enjoy positive learning experiences whilst listening to, and participating in, stories, reading and writing (usually in at least two languages).

The innate story-telling ability of all people and their affinity for engaging in this activity is the basis of this literacy initiative (Bloch, 2006 describes the value of stories in literacy development). With a strong emphasis on the role of emotion and play, club meetings involve telling stories (including singing and rhyming etc) which is extended into reading (simultaneously the range of reasons one might read is explored) and then into writing (again for different purposes) (Xolisa Guzula, pers. comm., Nal'ibali workshop, July 20, 2010, Durban). Such a reading club can be initiated and run (with training and continued support from the Nal'ibali staff) by any literate community member; the only criteria being that they should love children, reading and telling stories.

The initiative is supported by Biblionef, a book donation agency, which provides new books to impoverished schools in townships, informal settlements and in remote rural areas. Children's books are made available in all 11 official South African languages. Nal'ibali also is partnered with Avusa Media Limited, the publisher of a range of daily newspapers and other popular media, which provide a variety of resources including supplements which can be folded into simple books (usually in more than one language), accessible to anyone who can walk to a nearby Spaza shop and who has a couple of rand to spend. Surely this is the innovation that South African education needs? Although my own research recorded in this dissertation started out in a very different place, it has led me to this point - with the conviction that investment in such early child literacy initiatives are my own, personal future.

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APPENDICES

Appendix A

Values of Senior Certificate (SC) Symbols and Calculation of the Admission Points Score (APS) before the Implementation of the NSC in 2008

Symbol	Percentage achieved in school subject*	Points value for calculation of UKZN Admission Points Score (APS)**	
		Higher Grade	Standard Grade
A	80% - 100%	8	6
B	70% - 79%	7	5
C	60% - 69%	6	4
D	50% - 59%	5	3
E	40% - 49%	4	2
F	30% - 39%	3	1
G	<30%	-	-

* Umalusi (2005)

** UKZN (2009)

For students to have been awarded a Senior Certificate with matriculation endorsement they need to have taken a minimum of 6 subjects at Higher or Standard Grade; two of these were required to be official languages, both requiring a pass (above F) at Higher Grade. At least two of the remaining subjects should have been passed at Higher Grade; a minimum aggregate requirement is also applied (Umalusi, 2005).

All 6 subject results are included in the calculation of the Admission Points Score (APS). If a 7th subject was passed with a symbol of at least ‘E’ on HG or ‘D’ on SG, a bonus of 2 points is added to the point score (UKZN, 2009).

Note. Students scoring below F are only considered for the Access foundation streams under special circumstances (see minimum criteria for selection in Table 2).

Appendix B

Values of National Senior Certificate (NSC) Levels and Calculation of the Admission Points Score (APS)

NSC Rating (level of performance)	Description of competence	NSC percentage*	Calculation of Admission Points Score (APS)**	
			Points value	Adjusted percentages for UKZN
			8	90% - 100%
7	Outstanding	80% - 100%	7	80% - 89%
6	Meritorious	70% - 79%	6	70% - 79%
5	Substantial	60% - 69%	5	60% - 69%
4	Adequate	50% - 59%	4	50% - 59%
3	Moderate	40% - 49%	3	40% - 49%
2	Elementary	30% - 39%	2	30% - 39%
1	Not achieved	<30%	1	<30%

* Umalusi (2008)

** UKZN (2009).

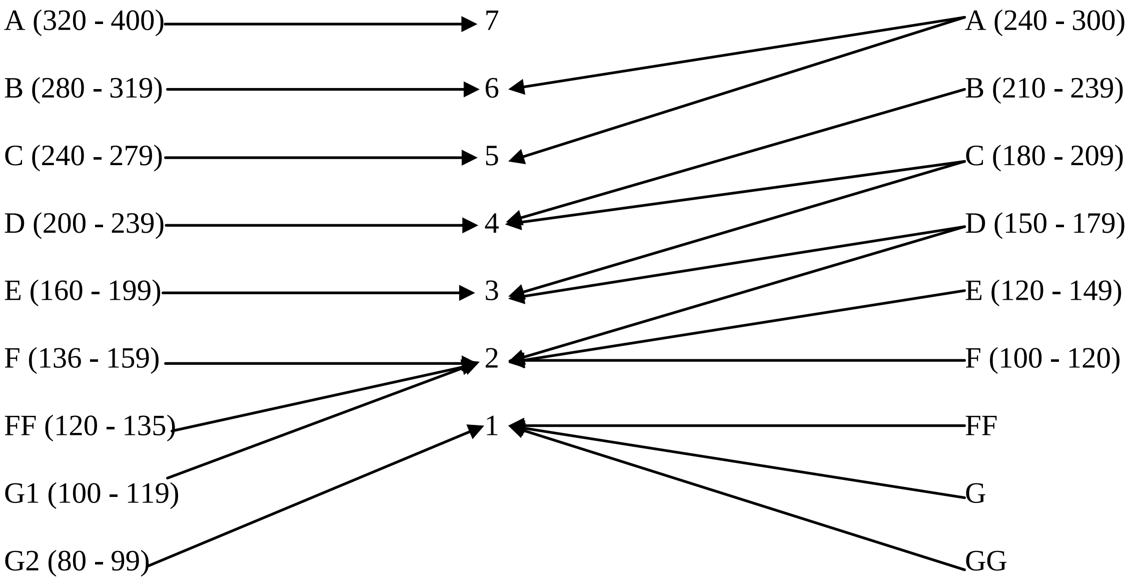
For students to have been awarded a National Senior Certificate (NSC) that fulfils the minimum requirements for admission to a bachelor's degree (NSC Deg), they need to have taken a minimum of 7 subjects (including Life Orientation). A minimum of level 4 must have been achieved in the language of learning and teaching of the higher education institution (English in the instance of UKZN). In addition, an achievement rating of 4 or better in four subjects from a designated list (Umalusi, 2008) is required.

Life Orientation is not included in the calculation of the Admission Points Score (APS) at UKZN, although a minimum of a level 4 is required for this subject. The remaining 6 subject results are included in the calculation of the APS. UKZN recognizes academic excellence by awarding 8 points to a subject with a performance level of 90-100% (UKZN, 2009).

Appendix C

Normalization of Values of Senior Certificate (SC) Symbols and NSC Levels

Senior Certificate Higher Grade (400)	National Senior Certificate level system	Senior Certificate Standard Grade (300)



The above table has been developed by Umalusi to allow for comparison across the Senior Certificate and the National Senior Certificate (Naidoo, 2010). The model has been used to calculate Admission Point Scores (APS) (both total “matric scores” and scores for individual subjects) for the 2009 mainstream cohort in the current research where students entered from both schooling systems. This has allowed parity in scores across the cohort.

Appendix D

Curriculum of a Student Augmenting Biology and Chemistry in Their First Year (UKZN Faculty of Science and Agriculture Handbook, 2011)

BIOL195 P1 W1 - Smaller Side of Life (Augmented)

(78L-78T-76P-0S-17H-60R-0F-0G-11A-13W-16FC-16DC)

Aim: To introduce structure, function and synthesis of biological molecules, structure and function of cells, introductory classical genetics.

Content: This module is available only to students registered for the BSc4 (Augmented stream). It covers the syllabus of BIOL101 but, in addition, includes a substantial amount of supplementary material and tuition designed for students who are under-prepared for university-level studies to a maximum of 160 additional hours.

Practicals: See BIOL101.

Assessment: Tests/assignments (20%), practical reports (20%), 3 h practical test (10%), 3 h theory exam (50%).

DP Requirement: Class mark of 40%, attendance at 80% of tutorials and practicals.

Subminimum to pass: 40% in each exam. Credit may not be obtained for BIOL195 and BIOL101. This module is worth 16 degree credits and 16 foundation credits.

BIOL196P2 W2- Life on Earth (Augmented)

(78L-78T-76P-0S-17H-60R-0F-0G-11A-13W-16FC-16DC)

Aim: To develop basic knowledge and understanding of the diversity of organisms, their origin and their importance.

Content: This module is available only to students registered for the registered for the BSc4 (Augmented stream). It covers the syllabus of BIOL102 but, in addition, includes a substantial amount of supplementary material and tuition designed for students who are under-prepared for university-level studies to a maximum of 160 hours.

Practicals: See BIOL102.

Assessment: Tests/assignments (30%), practical reports (20%), 3 h theory exam (50%).

DP Requirement: Class mark of 40%, attendance at 80% of tutorials and practicals.

Subminimum to pass: 40% in exam. Credit may not be obtained for BIOL196 and BIOL102. This module carries 16 degree credits and 16 foundation credits.

CHEM195 P1 W1- General Principals of Chemistry

(72L-18T-72P-0S-86H-60R-0F-0G-12A-13W-16FC-16DC)

Aim: To introduce the principles and practice of chemistry.

Content: This module is available only to students registered for the Augmented stream of the BSc4. It covers the syllabus of CHEM110 but, in addition, includes a substantial amount of supplementary material and tuition designed for students who are under-prepared for university-level studies to a maximum of 160 hours.

Practicals: Volumetric analysis, measurement of physical quantities, shapes of molecules.

Assessment: Tests (8%), quizzes (3%), practical reports (22%), 3 h exam (67%).

DP Requirement: Class mark of 40%, 80% attendance at practicals, 100% attendance at tests. Credit may not be obtained for CHEM195 and either of CHEM110 orCHEM161. This module is worth 16 degree credits and 16 foundation credits.

CHEM196 P2 W2- General Principals of Chemistry

(72L-18T-72P-0S-88H-60R-0F-0G-10A-13W-16FC-16DC)

Prerequisite: At least 40% in CHEM110 or CHEM195.

Aim: To present the physical and descriptive inorganic and organic aspects of introductory chemistry.

Content: This module is available only to students registered for the registered for the Augmented stream of the BSc4. It covers the syllabus of CHEM120 but, in addition, includes a substantial amount of supplementary material and tuition designed for students who are under-prepared for university-level studies to a maximum of 160 hours.

Practicals: Physical measurements, qualitative analysis, organic techniques.

Assessment: Tests (8%), quizzes (3%), practical reports (22%), 3 h exam (67%).

DP Requirement: Class mark of 40%, 80% attendance practicals, 100% attendance at tests. Credit may not be obtained for CHEM196 and either of CHEM120 or CHEM171. This module is worth 16 degree credits and 16 foundation credits.

Appendix E

Foundation Programme Modules as They Appear in the UKZN Faculty of Science and Agriculture Handbooks (2010 and 2011)*

Students meeting the BSc-4 (Foundation) requirements register for the 199 modules. Those students in the Science Foundation Programme stream register for the 099 modules. In practice however, students attend the same classes. Note the difference in credits earned on completion of the modules.

* Bold type-face indicates changes made in 2011

BIOL199 PY WY- Foundation Biology
BIOL099 PY WY- Foundation Biology
(31L-27T-81P-0S-55H-30R-0F-0G-16A-26W-20FC-4DC)
(31L-27T-81P-0S-55H-30R-0F-0G-16A-26W-24FC-0DC)
Corequisite: CHEM199/099, MATH 199/099, PHYS199/099, SCOM103/003 or 113/013).
Aim: To develop practical and cognitive science process skills, and basic content in biology.
Content: Nature of Life and biology; diversity & classification of living organisms; continuity of Life, ecological organization; cell structure and function; Science of Biology; natural selection and evolution; the rocky shore ecosystem; selected aspects from botany or zoology to teach generic academic skills.
Practicals: Related laboratory work and field excursions.
Assessment: Practical work, tests, essays, exercises (24%); June theory & practical tests (10%); 3 h theory exam (33%); 3 h practical exam (33%).
***Assessment:* June mark (15%), practicals, assignments and tests (15%); 3 h November practical test (20%); 3 h exam (50%).**
DP Requirement: Class mark of 40%; 80% attendance at all lectures, tutorials, practicals and field excursions.
Year-long Module.

CHEM199 PY WY - Foundation Chemistry
CHEM099 PY WY - Foundation Chemistry
(60L-20T-65P-0S-25H-50R-0F-0G-20A-26W-20FC-4DC)
(60L-20T-65P-0S-25H-50R-0F-0G-20A-26W-24FC-0DC)
Corequisite: BIOL199/099, MATH199/099, PHYS199/099, SCOM103/003 or 113/013).
Aim: To ensure that students with an inadequate grounding in chemistry develop a level of theoretical knowledge and practical and problem-solving skills to enable them to succeed in a BSc programme.
Content: Energy and matter; substances- elements, compounds and mixtures; chemical reactions; solutions-solubility and concentration; separation of mixtures; atomic structure- electronic configuration and the Periodic Table; compounds- bonding and nomenclature; the mole; reactions in aqueous solution.
Practicals: Observation and measurement.
Assessment: Tests (21%), Practicals (12%); 3 h exam (67%).
DP Requirement: Class mark of 40%; 80% attendance at all lectures, tutorials, practicals and field work.
Year-long Module.

MATH199 PY WY- Foundation Maths
MATH099 PY WY - Foundation Maths

(107L-65T-0P-0S-135H-74R-0F-0G-19A-26W-36FC-4DC)
(107L-65T-0P-0S-135H-74R-0F-0G-19A-26W-40FC-0DC)

Corequisite: CHEM199/099, BIOL199/099, PHYS199/099, SCOM103/003 or 113/013).
Aim: MATH 199/099 forms part of a package of modules for the Science Foundation Programme. It provides a foundation for all first year mathematics modules.
Content: Numerical and algebraic skills. Set theory. Equations and inequalities. Perimeter, area and volume. Numbers. Proportional reasoning. Functions: linear, quadratic, semi-circles, rectangular, hyperbola, piecewise functions, absolute values, circular (trigonometry), exponential, logarithmic. Introduction to differential calculus and word problems.
Assessment: Class mark (Assignments, class tests, 3 h June test, and tutorial tests) (50%); 3 h November exam (50%).
DP Requirement: Class mark of 40%; 80% attendance at all lectures and tutorials.
Year-long Module.

PHYS199 PY WY - Foundation Physics
PHYS099 PY WY - Foundation Phyics

(30L-9T-99P-0S-66H-33R-0F-0G-3A-26W-20FC-4DC)
(30L-9T-99P-0S-66H-33R-0F-0G-3A-26W-24FC-0DC)

Corequisite: BIOL199/099, MATH199/099, CHEM199/099, SCOM103/003 or 113/013).
Aim: To provide students from disadvantaged educational backgrounds with scientific reasoning, problem solving and laboratory skills in Physics to enable them to pursue a BSc degree.
Content: Experimental investigations of properties of matter, scalars and vectors, electrostatics and current electricity, graphs and equations of motion, Newton’s laws of motion and gravitation, a research topic and an elective.
Practicals: Experimental techniques and investigations.
Assessment: Class mark (50%), 3 h final exam (50%).
DP Requirement: Class mark of 40%; 80% attendance at all lectures, tutorials and practicals.
Year-long Module.

Appendix F

Corequisite Academic Literacy Modules for Foundation and Augmented Programme Students as They Appear in the UKZN Faculty of Science and Agriculture Handbook (2010 and 2011)

Foundation students in the SFP stream of the Foundation Programme register for SCOM003 PY WY ***or*** SCOM013 PY WY
Foundation students in the foundation stream of the BSc-4 Programme register for SCOM103 PY WY ***or*** SCOM113 PY WY
Augmented students in the augmented stream of the BSc-4 Programme register for SCOM101 P1 W1 ***and*** SCOM102 P2 W2 ***or*** SCOM111 P1 W1 ***and*** SCOM112 P2 W2

In practice, the Communication in Science modules are identical and the two streams of foundation students attend the same classes. Similarly, the Scientific Writing and Reporting modules are identical, and those foundation students that meet the test entrance requirements for this module attend the same classes.

SCOM003 PY WY - Communication in Science
SCOM103 PY WY - Communication in Science
SCOM101 P1 W1 - Communication in Science and SCOM102 P2 W2 - Communication in Science

(0L-40T-48P-0S-72H-0R-0F-0G-0A-26W-16FC-0DC)
(0L-40T-48P-0S-72H-0R-0F-0G-0A-26W-0FC-16DC)
(0L-20T-24P-0S-36H-0R-0F-0G-0A-13W-0FC-8DC) + (0L-20T-24P-0S-36H-0R-0F-0G-0A-13W-0FC-8DC)

Aim: To develop students' control of grammatical and discourse competence in English to improve their ability to read basic scientific texts, to write and to give oral presentations in science.
Content: Attention will be given to areas of grammatical and discourse competence in English that present difficulties for speakers of English as a second language. Through the process of short research projects relating to science, students will be supported in their reading in order to understand the purpose of a range of scientific texts. They will test their understanding of these genres by writing lab reports, essays and posters. There may also be a field trip.
Assessment: 100% Continuous-written assignments (60%), tests (25%), oral presentations (15%).
DP Requirement: Not applicable
These modules have no exams. In order to pass, students must attend 80% of classes and complete all assignments.

SCOM013 PY WY – Scientific Writing and Reporting
SCOM113 PY WY - Scientific Writing and Reporting
SCOM111 P1 W1 - Scientific Writing and Reporting AND SCOM112 P2 W2 - Scientific Writing and Reporting

(0L-40T-48P-0S-72H-0R-0F-0G-0A-26W-16FC-0DC)
(0L-40T-48P-0S-72H-0R-0F-0G-0A-26W-0FC-16DC)
(0L-20T-24P-0S-36H-0R-0F-0G-0A-13W-0FC-8DC) + (0L-20T-24P-0S-36H-0R-0F-0G-0A-13W-0FC-8DC)

Aim: To develop students' ability to access and read scientific sources, and their ability to write and make oral presentations in science.
Content: Short research projects relating to science. Scientific Writing and Reporting is a practical module in which students improve their writing through practical experience of a number of different kinds of writing: essays, reports and poster. There may also be a field trip.
Assessment: 100% Continuous-written assignments (60%), tests (25%), oral presentations (15%).
DP Requirement: Not applicable
These modules have no exams. In order to pass, students must attend 80% of classes and complete all assignments.

Appendix G

The Foundation Biology Module Tutorial Component: Units, Content and Outcomes (from 2006 to 2011)

Week	Unit	Contact sessions	Tutorials	OUTCOMES	
				Skill development	**Content knowledge**
1	1	1	What is Biology?	• understanding *[1] • participation in discussion	• learn terminology • general knowledge • general biological knowledge
		4	What is Life?	• understanding • listening and comprehension; reading and comprehension • summarizing using concept maps • participation in discussion • critically examine prior assumptions • develop empathy for living world and appreciation for Man’s impact on the Earth	• learn terminology • general knowledge • general biological knowledge
2		1	Organization of Life	• conceptual understanding • reading and comprehension	• learn terminology • general biological knowledge
2/3	2	3	Science of Biology	• develop an appreciation of science as human construction • develop an appreciation for the fallibility of science • perform hypothetico-deductive reasoning • basic experimental design • development of scientific ethics • reading and comprehension	• learn terminology • general science knowledge
4		3	Science of Biology	• ask questions, formulate hypotheses • identify variables • interpret results and draw conclusions • present results in appropriate tables and graphs	
5		4	Scientific Report writing	• report critique and report writing • report writing	
6/7	3	4	Cells: Basic Cell features and cellular structure	• interpretation of micrographs • appreciation for the scale of microscopic material • calculation of cell size • interpretation of structure and function • lecture-note taking	• learn terminology • specific biological knowledge
8/9		4	Animal and plant tissues	• interpretation of structure and function • lecture-note taking	• learn terminology • specific biological knowledge

10	3	2	DNA	• conceptual understanding • interpretation of diagrams • lecture-note taking	• learn terminology • specific biological knowledge
11		3	Genes to proteins	• conceptual understanding • interpretation of diagrams • lecture-note taking • synthesis	• learn terminology • specific biological knowledge
12/13		3	Continuity of Life	• conceptual understanding • synthesis	• learn terminology • specific biological knowledge
14		1	Unicellular and multicellular organisms	• synthesis • participation in discussion • write coherently • interpretation of structure and function	• general biological knowledge • specific biological knowledge
SEMESTER 2					
1	Essay unit	1	Essay writing skills	• topic analysis • research and library skills • essay writing skills	• general knowledge • general biological knowledge
	4	2	*Reading to complete tasks*	• read for understanding, • extract relevant information • make comparisons	• learn relevant terminology
2		1	Life’s diversity: Life’s Six Kingdoms	• understanding • reading and comprehension • write coherently • make comparisons • logic and deduction	• learn terminology • specific biological knowledge
2/3		3	Life’s diversity: Taxonomy	• understanding • reading and comprehension, write coherently • logic and deduction • make comparisons • interpret information • understand relationships • classification • use of keys for identification • participation in discussion	• learn terminology • general biological knowledge

3	4	2	*Classification 1*	• group objects in a hierarchy • show hierarchical relationships by means of branching diagrams and Venn diagrams	• learn terminology associated with classification • learn about hierarchical organization
4	5	1	Sampling	• understanding • reading and comprehension • deduction	• learn relevant terminology
4/5		4	Ecology: What sustains Life on Earth?	• conceptual understanding • reading and comprehension • write coherently • logic and deduction • ethics and social responsibility • basic numerical skills • interpretation of graphs and diagrams • participation in discussion	• learn terminology • general knowledge • general biological knowledge
5		1	*Introduction to the Rocky shores*	• preparation for the field trip • conceptual understanding	• learn terminology • general knowledge • general biological knowledge
6/7	6	5	Evolution Age of the Earth, History of Life, The fossil record	• critically examine prior assumptions • broaden world view and general knowledge • participation in discussion • reading and comprehension • gain an appreciation for the scale of geological time • interpretation of diagrams • link topics	• general knowledge
7/8/9		5	Life begins, evolution of life from unicellular to multicellular organisms, colonization of land	• critically examine prior assumptions • broaden world view and general knowledge • participation in discussion • reading and comprehension • gain an appreciation for the scale of geological time • interpretation of evidence • logic and deduction • summarizing using concept maps	• general knowledge • general biological knowledge

9	6	4	Natural selection and adaptation	critically examine prior assumptions conceptual understanding participation in discussion and natural selection modelling *reading, comprehension and synthesis*	general knowledge general biological knowledge specific biological knowledge
		1	What is a species?	critically examine prior assumptions conceptual understanding participation in discussion	specific biological knowledge
10/11	7	6	Evolutionary plant trends	conceptual understanding reading, comprehension and synthesis adaptation to lecture mode delivery note taking	general biological knowledge specific biological knowledge
12/13	8	6	Evolutionary animal trends	conceptual understanding reading, comprehension and synthesis adaptation to lecture mode delivery note taking	general biological knowledge specific biological knowledge

Notes.

*1 The term “understanding” refers to a student’s ability to extract meaning from a tutorial rather than to rote learn in a superficial manner.

The term “comprehension” is used to describe a student’s ability to meaningfully engage with the material and extract relevant information from it to complete a specific task.

The term “conceptual understanding” refers to a student’s ability to engage with information within a broad context.

2 Notional study hour allocation for the module allows for limited time to be spent on preparation for tutorials and summative assessment thereof. This allows for preparation of selected tutorials only – a preparation timetable is provided to students for this purpose. Selected tutorial exercises are submitted for contribution towards the continuous assessment mark; these are rotated annually. However, all can be done for students own learning purposes (self assessment) as the memoranda are made available to students after each tutorial.

3 Tutorials presented in italics are situated within the “Marine Theme” – these articulate directly with the practical component of the second semester.

Appendix H

The Foundation Biology Module Practical Component: Units, Content and Outcomes (2006-2011)

Week	**Unit** *1:	**Practicals**	**OUTCOMES**	
			Practical skills	**Cognitive skills**
1	-	Introductory Practical	• make correct and careful observations • make an accurate drawing of a suitable size • draw with neat, clear lines • draw in correct proportion • use annotations correctly to effectively enhance a drawing	• distinguish relevant detail • distinguish between a label and a descriptive annotation
2/3		Interpretation and Presentation of Data (3 practicals)	• follow scientific conventions for presenting data • compile a meaningful table from raw data • draw a graph with an appropriate scale, axes, title, accurately plotted points	• distinguish between independent and dependent variables • distinguish between continuous and discrete data • use line graphs and bar graphs appropriately • interpret data presented in tables and graphs
3	2	Aids: Interpreting and Presenting Data	• make careful observations • follow scientific conventions for presenting data • compile a summary table from raw data • draw graphs with appropriate scale, axes, title, accurately plotted points etc	• AIDS awareness • distinguish between independent and dependent variables • distinguish between continuous and discrete data • use line graphs and bar graphs appropriately • interpret data presented in tables and graphs
4	2	Science of Biology 1 (2 practicals)	• identify variables, control variables • design and conduct an experiment • collect data • present data/ results in appropriate tables and graphs	• make observations • ask questions • hypothetico-deductive reasoning, formulate hypotheses • analyse and interpret results • draw conclusions based on results • recognize experimental limitations and uncertainties
		Science of Biology 2	• identify variables, control variables • conduct an experiment • collect data • present data/ results in appropriate tables and graphs	• design experiment • hypothetico-deductive reasoning, formulate hypotheses • analyse and interpret results • draw conclusions based on results • recognize experimental limitations and uncertainties

5	2	Science of Biology 3: Report Writing	write a scientific report *2	write a scientific report
	-	FIELDTRIP to Bisley Nature Reserve	use equipment associated with collecting field data	interact with senior students to gain insight into biological research methods and career possibilities stimulate an intrinsic interest in biology develop an appreciation for the natural world and a conservation ethic
6	3	Microscope 1	use the compound microscope confidently and correctly make correct and careful observations identify relevant detail	have a basic understanding of the parts of the compound microscope and their functions begin to understand the relationship between field of view and magnification
		Microscope 2	cut longitudinal and transverse sections prepare a wet mount practise microscopy skills make correct and careful observations practise drawing skills	identify relevant detail to enable good labelling and annotations exposure to EM unit
7		Microscope 3		have a working understanding of the metric system to make conversions between different units determine real size of specimens in drawings from scale bar or magnification indicators calculate magnification of drawings from known real size
		Microscope 4	confidently prepare a wet mount accurately manipulate the compound microscope measure the size of the field of view at 10x and 40X	accurately estimate the real size of microscopic specimens calculate magnification of drawings *2
8		Cell Structure (2 practicals)	prepare wet mounts of plant and animal material manipulate compound microscope make accurate and careful observations identify cellular structures in plant and animal cells draw, label and annotate drawings tabulate information	compare and contrast features in different cell types relate structure of cells to their function calculate real size of specimens calculate magnification of drawings

9	3	Plant tissues	• prepare wet mounts of plant material • manipulate compound microscope • make accurate and careful observations • identify cellular structures in plant cells • draw, label and annotate detailed drawings • tabulate information	• compare and contrast features in different cell types • relate structure of cells to their function • interpret staining reactions • calculate real size of specimens • calculate magnification of drawings
10		Animal tissues	• prepare wet mounts of animal material • manipulate compound microscope • make accurate and careful observations • identify cellular structures in plant cells • draw, label and annotate plan diagrams	• compare and contrast features in different cell types • relate structure of cells to their function • calculate real size of specimens • calculate magnification of drawings • interpret plan diagrams
11		Cell size (2 practicals)	• make measurements	• calculate surface area and volume • calculate surface area to volume ratios • understand why cells are small in terms of surface area and volume. • compare and contrast features in different cell types • relate structure of cells to their function
12		Cells- Listening for understanding (video)		• listening and comprehension
		Mitosis and Meiosis	• model processes	• Understanding the process of Mitosis and Meiosis
13		Unicellular and Multicellular organisms	• prepare and study wet mounts • make accurate and careful observations • identify relevant detail • annotate plan diagram	• recognize organisms using diagnostic features • distinguish between unicellular and multicellular organisms • calculate real size and magnification
SEMESTER 2				
1	-	OPAC	• use of the OPAC system and library	• interpretation of essay topic • literature search
2	4	*Classification 2*	• group objects in a hierarchical manner • show relationships between objects by drawing cladograms and Venn diagrams	• name the groups used in biological classification • correctly interpret cladograms

3	5	*Mode of Life*	• make correct and careful observations • identify specimens • tabulate information	• identify relevant information • synthesize information • learn terminology
4		Sampling	• make accurate observations • collect data in the field using an appropriate sampling technique • use the equipment accurately • compile tables and graphs	• identify variables and choose the most appropriate ways to present the data • interpret data
5/6/7	2/4/5	*Fieldtrip to the rocky shores and Ushaka Marine World*	• use the methods of scientific investigation in the field. • sample reliably using quadrats • collect and record quantitative data • make careful observations in the field • present data using suitable graphs and tables • write a scientific report	• read for understanding, • extract relevant information • formulate hypotheses • identify variables • analyse data • interpret and discuss results in the light of field observations • identify adaptations of organisms to their environments • make valid conclusions • develop an aesthetic appreciation for the marine environment and a conservation ethic
8	3/4/5	*Protista*	• prepare and study wet mounts of live specimens using appropriate techniques and stains • identify relevant detail using the compound microscope • estimate real size of microscopic material • use a dichotomous key • prepare a branching diagram to reflect the relationships between the specimens	• correctly identify specimens on the basis of distinguishing characteristics • develop a working understanding of the difference between natural and artificial classification. • recognise some protists and distinguish between unicellular, multicellular and colonial organisms
9	6/7	Evolutionary trends in plants	(Visit to Botanical Gardens) • make correct and careful observations • use botanical key	• identify characteristics of primitive and advanced plants • draw links between observable characteristics and evolutionary trends in plants • develop an appreciation for the diversity of plants • relate a plant's adaptive structures to it ability to survive in a particular environment. • understand how these adaptive characteristics have evolved over millions of years through natural selection • link topics, make comparisons, learn terminology

10	2/6/7	Transpiration-illustrating adaptation	• conduct an experiment • manipulate apparatus effectively • make correct and careful measurements • record measurements • present results in appropriate tables and graphs • write a scientific report *[2]	• experimental design • set hypotheses • identify variables • make calculations • interpret results • discuss results
11	6/8	Trends in animal evolution	• detailed observation • specimen identification and tabulation	• learn terminology • identify relevant observation • organize and synthesize information
12	Revision			

Notes.

*1 Practical component requires students to relate the theory learnt in tutorials to their practical experience in the laboratory

*2 For some of the practicals it is difficult to distinguish whether the skills gained are cognitive or practical. Report writing and the calculation of magnification are two such examples where such overlap will exist

Appendix I

Correspondence with the Dean's office, Faculty of Science and Agriculture, UKZN, Granting Permission to Conduct Research, and use Data as Requested

>>> Christel Barnard 2009/03/10 09:57 AM >>>
Dear Nicki

I fully support the research that you are undertaking. I think it will provide some insight on factors affecting the performance of our 1st year students. Permission to use the data request is granted subject to you filling the required Ethical Clearance documents from the Research Office. If this has been done, then regard this as permission to go ahead your research using the data.

Best of luck in your research.

Regards.

Yours sincerely
Professor D Jaganyi
Acting Dean, Faculty of Science and Agriculture

>>> Nicola Kirby 2009/03/09 01:31 PM >>>
Dear Christel
I would be very grateful if you could relay the attached letter to Professor Jaganyi. The letter concerns my current application for ethical clearance for the research that I am conducting on the factors affecting student performance in First year and Foundation Biology modules.

There are various aspects to my research, but the particular data that I require permission from Prof Jaganyi to use are the science and maths selection scores of the CSA Foundation students and these students' final marks for the Foundation modules.

I have attached my research proposal for Professor Jagnayi's perusal should he wish to do so.

Many thanks
Regards
Nicki Kirby

Coordinator, Foundation Biology
Science Foundation Programme
University of KwaZulu-Natal
Private Bag X01
Scottsville
Pietermaritzburg
3209

Appendix J

Letter Confirming Permission to use Data on SMS System

Mrs N Kirby
School of Biological and Conservation Sciences
University of KwaZulu-Natal
Pietermaritzburg

RE: PERMISSION TO USE STUDENT DATA ON THE SMS SYSTEM

Dear Mrs Kirby

I hereby give my full support to you to conduct research on the factors affecting student performance in First year and Foundation Biology modules. This support includes permission to use relevant data stored on the university electronic systems relating to students' matric results, demographic information such as gender and home language, and their final marks for the level 1 Biology modules.

I look forward to seeing the results of your research, and would like to invite you present the results formally to the school once you have completed the research.

Yours sincerely

Professor K P Kirkman
Head: School of Biological and Conservation Sciences

School of Biological and Conservation Sciences (Pietermaritzburg Campus)
Postal Address: Private Bag X01, Scottsville, 3209 South Africa
Telephone: +27 (0)33 260 5104 **Facsimile:** +27 (0)33 260 5105 **Email:** sbcs@ukzn.ac.za **Website:** http://www.ukzn.ac.za/biology
Founding Campuses: 🟥 **Edgewood** 🟧 **Howard College** 🟨 **Medical School** 🟩 **Pietermaritzburg** 🟦 **Westville**

Appendix K

Correspondence with the Dean of Students Office, UKZN, Granting Permission to Conduct Research, and Use Data as Requested

Dear Nicola

Sorry, seems to have been a gremlin in the system. I responded to your request via Groupwise on my cellphone, but the message does not seem to have been developed. My apologies.

Permission was granted for you to have access to the student data as requested.

Regards
Trevor Wills
Executive Dean (Students)

\>>> Nicola Kirby 2009/03/06 11:55 AM >>>
Dear Mr Wills
I am currently applying for ethical clearance for the research that I am conducting on the factors affecting student performance in First year biology and Foundation modules. DMI have informed me that they require permission to be granted by you before they can release permission to me to use the data. The data that I need to access is that which is available on the ERS- students' matric results, demographic information such as gender and home language, and their final marks for the BIOL 101, and foundation modules. I have access to the final marks via SMS as a co-ordinate the foundation biology modules and track these students progress into the first year module. Even though I generate the data for the Foundation modules, I understand that it belongs to the University.

I have attached my research proposal for your perusal should you wish to do so.

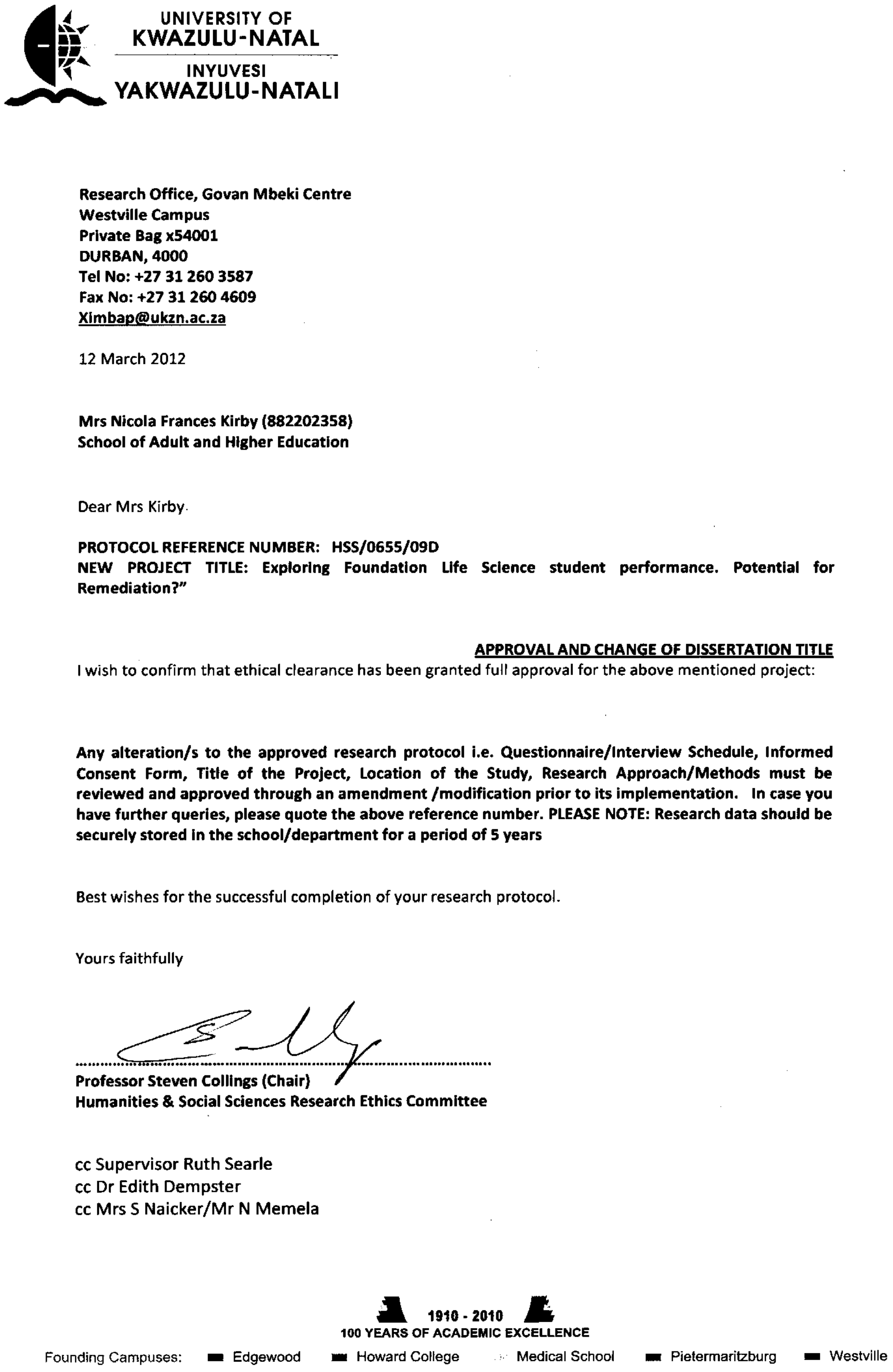
I would be very grateful if you would grant permission to me to use this data. All data will be treated as confidential; I do not need to collect data according to the students' names, and in fact once I collate the data, I can dispense with the student number as well.

Many thanks
Regards
Nicki Kirby

Coordinator, Foundation Biology
Science Foundation Programme
University of KwaZulu Natal
Private Bag X01
Scottsville
Pietermaritzburg
3209

Appendix L

Confirmation of Ethical Clearance for Research as Doctoral Study



UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

Research Office, Govan Mbeki Centre
Westville Campus
Private Bag x54001
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Tel No: +27 31 260 3587
Fax No: +27 31 260 4609
Ximbap@ukzn.ac.za

12 March 2012

Mrs Nicola Frances Kirby (882202358)
School of Adult and Higher Education

Dear Mrs Kirby

PROTOCOL REFERENCE NUMBER: HSS/0655/09D
NEW PROJECT TITLE: Exploring Foundation Life Science student performance. Potential for Remediation?"

APPROVAL AND CHANGE OF DISSERTATION TITLE

I wish to confirm that ethical clearance has been granted full approval for the above mentioned project:

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach/Methods must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years

Best wishes for the successful completion of your research protocol.

Yours faithfully

……………………………………………………………………………
Professor Steven Collings (Chair)
Humanities & Social Sciences Research Ethics Committee

cc Supervisor Ruth Searle
cc Dr Edith Dempster
cc Mrs S Naicker/Mr N Memela

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: ■ Edgewood ■ Howard College ■ Medical School ■ Pietermaritzburg ■ Westville

Appendix M

Extract of Foundation Biology Module Evaluation indication Informed Content from students to participate in research

FOUNDATION BIOLOGY MODULE EVALUATION November 2008

Informed Consent

I hereby give my permission for the information below to be used for research purposes. I give this permission with the understanding that all my personal information will be kept completely confidential.

Student number:…………………………………………………….
Signature:

Date: ……………………………………

For questions 1 to 3 you are presented with a statement to which you should respond by **circling the letter** that gives your answer.

1. **Accommodation:**
   - A. I have been in Residence all year.
   - B. I was in Residence the first semester, but not the second
   - C. I was in Residence the second semester, but not the first
   - D. I rent accommodation in town while at University
   - E. I live at home while at University

I

2. **How far do you travel to University every day?**
   - A. I live in Residence so it is an easy walk.
   - B. I don't live in Residence, but it takes less than ½ hour to walk to University
   - C. I live off campus and I don't walk. It takes me **less** than 1 hour to get to University.
   - D. I live off campus and I don't walk. It takes me **more** than 1 hour to get to University.

3. **Financial support**
   - A. I have had no financial support this year at all.
   - B. I have received a partial bursary of R2000.00
   - C. I have received a partial bursary of between R2000.00 and R4000.00
   - D. I have received a partial bursary of between R4000.00 and R8000.00
   - E. I have received a full bursary (tuition only)
   - F. I have received a full bursary (tuition and accommodation)
   - G. I have received Financial Aid

Other, please specify…………………………………………………………………………..

CSA
Centre for Science Access
(BSc4 and Science Foundation programmes)

UNIVERSITY OF
KWAZULU-NATAL

SCHOOL of BIOLOGICAL and CONSERVATION SCIENCES

The following 15 questions are about how you felt about Foundation Biology. **Please be honest in your answers.** Your answers will, in no way, affect your performance in the Foundation Biology module.

In each question you are presented with a statement to which you should respond by placing **a cross** on the letter that gives your answer.

A= strongly agree B= agree C= not sure D=disagree E= strongly disagree

1	I have tried hard in Biology because I am interested in the subject.	**A**	**B**	**C**	**D**	**E**
2	I have tried hard to make sure that I perform well in Biology.	**A**	**B**	**C**	**D**	**E**
3	I work hard to try and understand something new in Biology.	**A**	**B**	**C**	**D**	**E**
4	The harder the task in Biology, the harder I try.	**A**	**B**	**C**	**D**	**E**
5	When I perform well in Biology, I try even harder.	**A**	**B**	**C**	**D**	**E**
6	I like to compete with others in Biology	**A**	**B**	**C**	**D**	**E**
7	I work hard in Biology so that I can do better than others in the subject	**A**	**B**	**C**	**D**	**E**
8	It is important for students to help each other in Biology	**A**	**B**	**C**	**D**	**E**
9	I like to help other students with their Biology work.	**A**	**B**	**C**	**D**	**E**
10	I enjoy helping other students with their Biology even if I don’t perform that well myself.	**A**	**B**	**C**	**D**	**E**
11	I want to perform well in Biology for own sense of achievement.	**A**	**B**	**C**	**D**	**E**
12	I want to perform well in Biology so I don’t let my parents/guardians down.	**A**	**B**	**C**	**D**	**E**
13	Having other people tell me that I have done well in Biology is important to me.	**A**	**B**	**C**	**D**	**E**
14	Understanding the work in Biology is more important to me than the mark I get for an assignment.	**A**	**B**	**C**	**D**	**E**
15	I want to do well in Biology this year because it will enhance my performance in first year.	**A**	**B**	**C**	**D**	**E**

Appendix N

Syntax for the Generation of Classification Rules to Predict 2009 Foundation Biology Performance from 2008 Regression Tree

```
/* Node 5 */
DO IF (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 76.349))  AND  (((VALUE(MSCORE) LE 45) OR
SYSMIS(MSCORE)  AND  (SYSMIS(LangSEL) OR (VALUE(LangSEL) GT 33.5))))  AND
(((VALUE(LangSEL) LE 53) OR SYSMIS(LangSEL)  AND  (SYSMIS(MSCORE) OR (VALUE
 (MSCORE) GT 39.5)))).
COMPUTE nod_001 = 5.
COMPUTE pre_001 = 44.304347826087.
END IF.
EXECUTE.

/* Node 6 */
DO IF (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 76.349))  AND  (((VALUE(MSCORE) LE 45) OR
SYSMIS(MSCORE)  AND  (SYSMIS(LangSEL) OR (VALUE(LangSEL) GT 33.5))))  AND
(((VALUE(LangSEL) GT 53) OR SYSMIS(LangSEL)  AND  (VALUE(MSCORE) LE 39.5))
 ).
COMPUTE nod_001 = 6.
COMPUTE pre_001 = 50.95.
END IF.
EXECUTE.

/* Node 7 */
DO IF (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 76.349))  AND  (((VALUE(MSCORE) GT 45)
OR SYSMIS(MSCORE)  AND  (VALUE(LangSEL) LE 33.5)))  AND  (VALUE(LangSEL) LE 38.5).
COMPUTE nod_001 = 7.
COMPUTE pre_001 = 49.33.
END IF.
EXECUTE.

/* Node 8 */
DO IF (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 76.349))  AND  (((VALUE(MSCORE) GT 45)
OR SYSMIS(MSCORE)  AND  (VALUE(LangSEL) LE 33.5)))  AND  (SYSMIS(LangSEL) OR
(VALUE(LangSEL) GT 38.5)).
COMPUTE nod_001 = 8.
COMPUTE pre_001 =
  56.2592592592593.
END IF.
EXECUTE.

/* Node 2 */
DO IF (VALUE(LangSEL) GT 76.349).
COMPUTE nod_001 = 2.
COMPUTE pre_001 = 72.33.
END IF.
EXECUTE.
```

Appendix O

Syntax for the Generation of Classification Rules to Predict a).2009 Foundation Chemistry Performance from 2008 Tree b) 2009 Foundation Physics Performance from 2008 Tree

a.

```
/* Node 3 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 56.0497))  AND  (VALUE(SMScore) LE
50.8494).
COMPUTE nod_001 = 3.
COMPUTE pre_001 = 47.421052631579.
END IF.
EXECUTE.

/* Node 4 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 56.0497))  AND  (SYSMIS(SMScore) OR
(VALUE(SMScore) GT 50.8494)).
COMPUTE nod_001 = 4.
COMPUTE pre_001 = 54.2647058823529.
END IF.
EXECUTE.

/* Node 2 */
DO IF (VALUE(SMScore) GT 56.0497).
COMPUTE nod_001 = 2.
COMPUTE pre_001 = 61.3461538461538.
END IF.
EXECUTE.
```

b.

```
/* Node 1 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 55.649)).
COMPUTE nod_001 = 1.
COMPUTE pre_001 = 51.0961538461539.
END IF.
EXECUTE.

/* Node 2 */
DO IF (VALUE(SMScore) GT 55.649).
COMPUTE nod_001 = 2.
COMPUTE pre_001 = 62.8518518518519.
END IF.
EXECUTE.
```

Note: SMScore denotes selection model score

Appendix P

Syntax for the Generation of Classification Rules to Predict 2009 Foundation Maths Performance from 2008 Tree

```
/* Node 3 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 56.55))  AND  (VALUE(SMScore) LE 50.85).
COMPUTE nod_001 = 3.
COMPUTE pre_001 = 54.74.
END IF.
EXECUTE.

/* Node 5 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 56.55))  AND  (SYSMIS(SMScore) OR
(VALUE(SMScore) GT 50.85))  AND  (VALUE(SMScore) LE 51.35).
COMPUTE nod_001 = 5.
COMPUTE pre_001 = 69.67.
END IF.
EXECUTE.

/* Node 6 */
DO IF (SYSMIS(SMScore) OR (VALUE(SMScore) LE 56.55))  AND  (SYSMIS(SMScore) OR
(VALUE(SMScore) GT 50.85))  AND  (SYSMIS(SMScore) OR (VALUE(SMScore) GT 51.35)).
COMPUTE nod_001 = 6.
COMPUTE pre_001 =
  58.55.
END IF.
EXECUTE.

/* Node 2 */
DO IF (VALUE(SMScore) GT 56.55).
COMPUTE nod_001 = 2.
COMPUTE pre_001 = 71.
END IF.
EXECUTE.
```

Appendix Q

Syntax for the Generation of Classification Rules to Predict 2009 Communication in Science Performance from 2008 Tree

```
/* Node 1 */
DO IF (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 64.25)).
COMPUTE nod_001 = 1.
COMPUTE pre_001 = 55.69.
END IF.
EXECUTE.

/* Node 3 */
DO IF (VALUE(LangSEL) GT 64.25)  AND  (SYSMIS(LangSEL) OR (VALUE(LangSEL) LE 76.35)).
COMPUTE nod_001 = 3.
COMPUTE pre_001 = 60.62.
END IF.
EXECUTE.

/* Node 4 */
DO IF (VALUE(LangSEL) GT 64.25)  AND  (VALUE(LangSEL) GT 76.35).
COMPUTE nod_001 = 4.
COMPUTE pre_001 = 68.67.
END IF.
EXECUTE.
```

Appendix R

Syntax for the Generation of Classification Rules to Predict 2009 Overall Average Foundation Mark from 2008 Tree

```
/* Node 1 */
DO IF (SYSMIS(Modelscr) OR (VALUE(Modelscr) LE 56.05)).
COMPUTE nod_001 = 1.
COMPUTE pre_001 = 53.23.
END IF.
EXECUTE.

/* Node 2 */
DO IF (VALUE(Modelscr) GT 56.05).
COMPUTE nod_001 = 2.
COMPUTE pre_001 = 61.89.
END IF.
EXECUTE.
```